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COMPUTERIZED SCHEDULING/BROKERAGE
DEMONSTRATION PROJECT IN VANCOUVER

APPLICATION OF COMPUTERS TO SPECIAL TRANSIT SERVICES

A Review

Prepared for the
Transportation Development Centre
and BC Transit

by TransVision Consultants Ltd.

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17. Abstract

A review of the application of computers to special transit services for the disabled is provided in this report. The various functions undertaken in the offices of an operator of special transit services are reviewed. These include: client registration, trip reservation, service scheduling, vehicle dispatching and operations monitoring. The setting and background of the various computer applications are described in the cities of Toronto, Montreal, Quebec, Sherbrooke, Ottawa, Edmonton, Hamilton and Victoria.

An analysis of each unique application is provided in terms of its functions, files, data elements, reports, features and performance. From this analysis, general trends in the application of computers to special transit services are derived and presented.

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17. Résumé

Ce rapport fait un tour d'horizon des possibilités d'application de l'ordinateur au transport adapté. Il passe en revue les fonctions assurées par une entreprise offrant des services de ce type: enregistrement de l'abonné, demande de déplacement, organisation des itinéraires, régulation des mouvements et suivi des opérations. Il décrit la mise en place de divers services de transport informatisés, dans le cas des villes suivantes: Toronto, Montréal, Québec, Sherbrooke, Ottawa, Edmonton, Hamilton et Victoria.

Il analyse chacune de ces applications dont il donne les particularités: fonctions, fichiers, traitement des données, production de rapports, caractéristiques et services offerts. De cette analyse, il tire une synthèse générale sur l'application de l'ordinateur aux services de transport adapté.

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1. INTRODUCTION

In March 1985, the Transportation Development Centre of Transport Canada and British Columbia Transit initiated a jointly-sponsored and jointly-funded computerized scheduling/brokerage demonstration project in Vancouver.

The overall objective of the project is to foster the development of technology to improve transportation services for elderly and handicapped persons. The specific project objective is to improve the quality and cost-effectiveness of transit services for the disabled through the selection, implementation and demonstration of computerized scheduling/ brokerage systems in Vancouver in time for Expo 86, an international transportation and communications exposition. Throughout the project, an emphasis is to be placed on the best application of microcomputer technology to the personalized form of transportation that is offered by special transit services.

The demonstration project is under the direction of a Steering Committee composed of representatives from Transport Canada's Transportation Development Centre, the Canadian Urban Transit Association, BC Transit, Alberta Transportation, the Ontario Ministry of Transportation and Communications, the Quebec Ministry of Transport, and the City of Edmonton. Operational inputs from transit service providers and users will be obtained through a Users Advisory Committee.

The overall project approach includes four phases: analysis of existing computer applications for special transit services, including examination and documentation of an existing computer-aided system developed by

BC Transit in Victoria; selection, installation and testing of two computer-aided scheduling systems for the Vancouver area; selection and enhancement of the most appropriate system; and, finally, implementation and expansion of the selected system in the entire Vancouver area.

The end products of the demonstration project are to include: several computer software packages for special transit service operators, including user manuals and tutorial programs; a series of reports on computer-aided scheduling of special transit services and the demonstration project; and, an audio-visual presentation on the results of the demonstration project.

The following report, one of the end products of the demonstration project, is a review of the application of computers to special transit services in Canada. In the report, an analysis is provided of computer applications in the cities of Toronto, Montreal, Quebec City, Sherbrooke, Ottawa, Edmonton, Hamilton and Victoria. The functions, files, reports, features and performance of each application is described.

SPECIAL TRANSIT SERVICES

Special transit services are generally demand-responsive transit services provided for individuals with disabilities sufficiently severe that they are physically unable, without assistance, to use conventional public transit with dignity. They are a parallel door-to-door transit service that is scheduled on a request basis for eligible users who telephone for service. Vans or small buses outfitted with wheelchair lifts are generally used. Lately, however, the use of taxis has been finding favour as a means of providing a supplementary and complementary service.

Private rehabilitation and charitable organizations were among the first to introduce special transit services for transporting disabled persons whose mobility was reduced. Because they were highly adaptable to time, space and quality requirements, special transit services were an obvious solution to the problem and thus were long regarded as an excellent means of solving the transportation problems of disabled persons.

Special transit services, by their very nature, are extremely management and labour-intensive. Operating on demand, in response to individual users' requests for service, requires extensive efforts to balance the demand with the supply and to ensure that each individual's transportation needs are being met in the most efficient manner possible.

Improvements in productivity and efficiency rely heavily on improvements in operations management. Much of the operations management effort is concerned with recording, retrieving, exchanging and displaying information. The manner in which information flows are dealt with

determines to a large extent the efficiency of the operation, the quality of the decision-making and the level of service that can be offered to the users of the system.

Improvements in custom transit services are often limited, not by demand (which is usually greater than the supply), but by the efficiency of operations. In fact, these services tend to rely fairly heavily on management and control of the demand by means of eligibility criteria, trip booking procedures, ride prioritization and other service constraints. Effective control of demand, although detrimental in some aspects to the effectiveness of the service, is a necessity with current operations management techniques to improve service efficiency.

Effective control of demand, with corresponding improvements in the quality of service, requires better time responsiveness in the manner in which information flows are dealt with. The speed with which information flows are accomplished is a major determinant of the quality of the service as viewed by the user.

APPLICATION OF COMPUTERS

The technological advances in the field of computer systems offers potential opportunities to improve the quality and speed of information flows within the operations management function of special transit services, thus offering some potential for short and long-term solutions to the increasing productivity and efficiency demands made on the management and operations personnel of these services by their funding agencies.

Operations management is concerned with vehicle productivity and with the overall quality of the services provided. By continuously enforcing efficiency in trip assignments, the computer could ensure that every trip is done as cost-effectively as the situation allows. The computer's speed and capability for total recall would ensure that no service commitment would be forgotten. This same capacity would also ensure that no new commitment would be permitted to violate a previous commitment, so the quality of service to each individual would always be protected. Finally, the computer's unique ability to make the service easier to manage would enable the service to maximize its trips each day so that the maximum possible fleet utilization would be realized. When this power of fleet management is coupled with the computer's management information capabilities, the result would be a potentially tremendous improvement in service efficiency and effectiveness.

Based on these premises, the application of computer technology to special transit services has been advocated as a means of improving economic effectiveness and operational efficiency, increasing service

productivity and reliability as well as increasing convenience to users (1)*. Although the systems are intended to increase productivity and minimize deadheading and wait time, the main value to date has been the ability to collect and retain data in a unified format, providing management with necessary information in a timely manner, thus improving financial, data and operations management of the service.

Recent experience in the application of computer technology, however, indicates that much depends on planning, forethought and on sensitivity to the operational environment of special transit services for the successful insertion of this technology. The workers in a special transit office usually have unique capabilities -- operating a computer system may not be one of them. Computer systems are becoming increasingly user friendly but they also have to meet the needs of the users of the service, as well as the operator to ensure a successful implementation. A concern is expressed that, if there is a reorientation of work from information processing to operating a computer, then very little will have been accomplished. What is required is a reorientation of work to tasks that take advantage of special transit operations personnels' unique capabilities in the areas of client relations, judgment, initiative and decision-making. Computers should be applied in a way that enhances, rather than replaces, the unique capabilities of special transit service operators in their dealings with their clients.

* The numbers in brackets designate the references which are listed at the end of the report.

2. SPECIAL SERVICES

Special transit services are generally demand-responsive transit services provided for disabled individuals. The aim underlying the provision of these services is to offer disabled persons a means of mobility that caters to the requirements of the passengers and provides them with access to the same opportunities as non-disabled individuals. On the other hand, good business management demands the allocation of several users to each vehicle in order to achieve a high degree of efficiency. A special transit service thus becomes a transport system that ranges between bus and taxi systems with trade-offs between efficiency and effectiveness required.

Operators of special transit services have four main functions to perform when delivering services to disabled individuals. These functions are necessary due to the constraints imposed by funding agencies and their predilection for efficiency, as well as the constraints relating to traffic conditions and the type of service being provided. The four main functions include: trip reservation, service scheduling, vehicle dispatching and operations monitoring (preparing reports).

To undertake the functions the operator of a special transit service might have reservationists, schedulers and dispatchers in the office in addition to clerical, secretarial and managerial staff, and, of course, the vehicle drivers. The reservationists would record and process requests for service which are normally received over the telephone. The schedulers would match service orders with vehicle resources. The dispatchers would transmit trip details and instructions to the drivers and monitor the status of the vehicle fleet. Finally, the clerical staff would record daily transactions in the office.

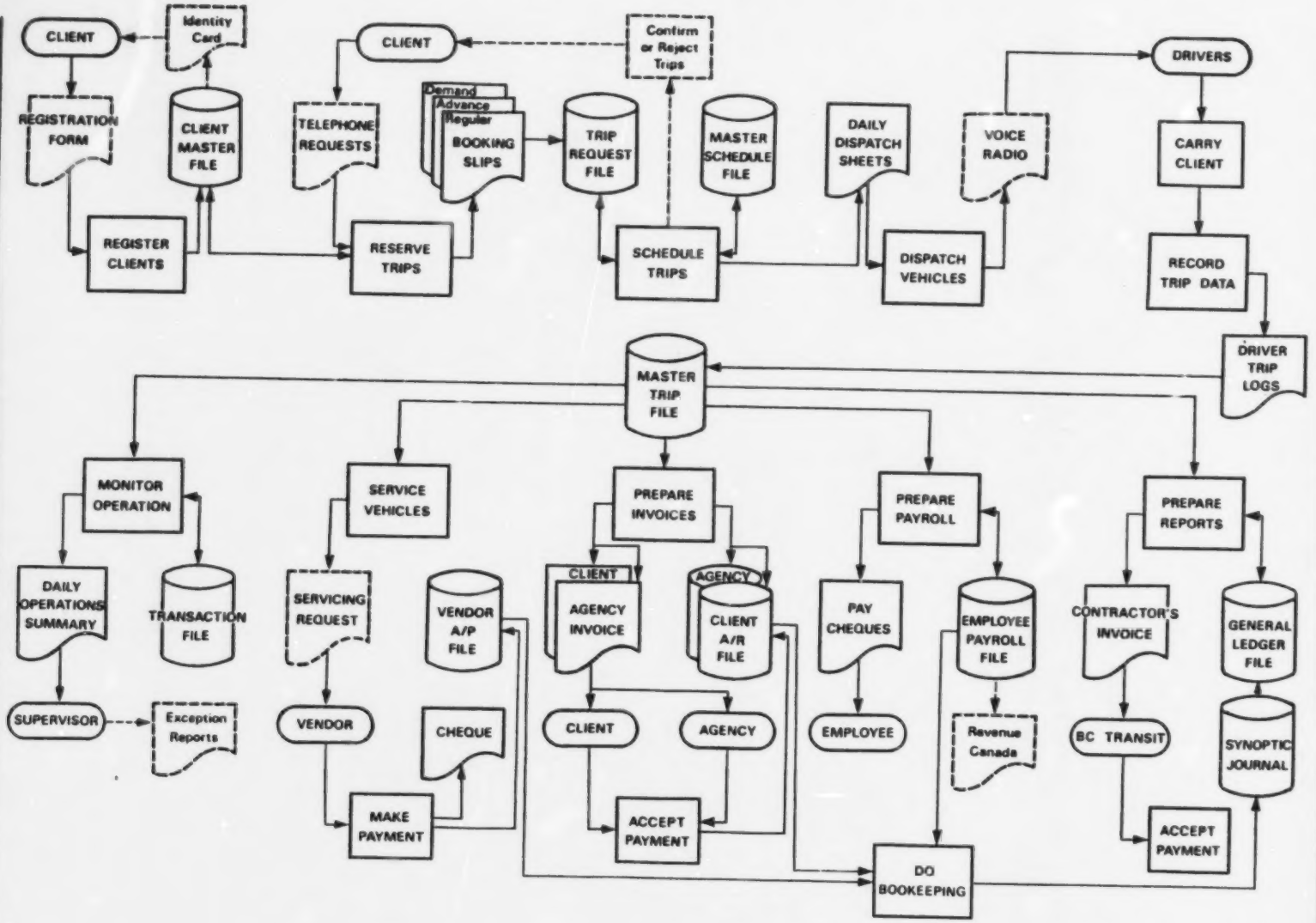


Exhibit 1: Information Flow in a Special Transit Service Office

The daily transactions are recorded in working files containing information on the operator's clients and their trip requests. In addition to these working files, there are a number of reference files and materials maintained by the operator (2). These include registration lists, vehicle and driver files, trip transaction files, and the usual collection of maps and street directories.

The control system of the special transit service performs the reservation, scheduling and dispatching tasks involved in the provision of the service. The system is a complex set of data storage, information processing, analysis and decision-making tasks. The overall objective of the control system is to improve service productivity and lower costs while maintaining effective control over the service as it grows.

In the course of carrying out the required functions each day, a huge amount of information is recorded, stored, manipulated and processed in a variety of forms by the various personnel. Not surprisingly, the management of this information system is the central element in determining the efficiency of the control office operations, the quality of the decisions that are made, and the level and quality of service offered to the clients of the service.

An information flow diagram depicting how documents are being created and amended, and the files that are affected, in a generalized special transit service office, is presented in Exhibit 1 on the opposite page. Before entering into a detailed description of each functional task, the system will be described in general terms.

The central element of special transit services is the schedule, or a set of scheduled runs, for a given day of operation. The schedule contains all the necessary information for each trip including the pickup time requested by the customer, the scheduled time, and, upon completion of a run, the actual time entered by the driver on his driver sheet. Most of the actions taken by the call-taker, scheduler, and dispatcher will pertain to these records.

Chronologically, the first action taken on a schedule for a given day is its creation. The scheduler will first create a master schedule based on the recurring subscription trips. When a client calls to reserve a trip for a given day, the call-taker will attempt to insert the trip into the master schedule for that day -- either at the time of the call or later. To do so, certain data in the schedule trip record will be modified as needed. This modification, however, is usually kept to a minimum by most operators since it is difficult to do and it would mean that clients would get a different driver and a different route each day.

Before the day of operation of a schedule, several other actions take place. The customer might call back to cancel the trip or simply to

inquire about the trip status. The call-taker will then record the cancellation request on a form or attempt to provide the requested trip status information to the customer.

After the current schedule is developed, a call-back confirmation process may be initiated. For the call-back confirmation process, the call-taker can review the list of trip booking slips, call each customer and confirm the trips. If the customer is not reached, the call taker can register that attempt and try again later. The call-back process simplifies route planning by allowing more time for the scheduler, but involves a complex and costly call-back procedure. A no call-back policy avoids this costly task, but necessitates an immediate analysis of the request. It is difficult to choose between these two approaches except when taxis are used as a supplementary service (3). In this case, all trips can normally be served and the call-back process is not required.

On the evening before the day of operation, the driver sheets will be produced from the schedule data. The driver sheets provide each driver with a detailed itinerary for their shift, listing the time, location and name of each passenger.

On the day of operation, the dispatcher will modify the current schedule to accommodate demand-responsive trips, late cancellations, no shows, unexpected delays and vehicle breakdowns. Also, on the day of operation, the driver run sheets are updated by the drivers with actual time, mileage and fare information for each trip. From this and his or her own records, the dispatcher can update the planned scheduled with the actual operational information.

From the actual operational information, various management information reports can be generated for funding agency reporting and operational monitoring purposes.

TRIP RESERVATION

Recording and processing requests for service is the reservationists' principal function and occupies the bulk of their time. Since this is a highly repetitive task, well-structured procedures are usually followed.

The amount of information that needs to be recorded for each trip request is quite extensive and includes: client name and registration number, telephone number, address of both trip origin and destination, number of persons, desired arrival time at destination, plus similar information for the return trip. In addition, information essential to assisting the passenger is requested, i.e. type of disability, necessary assistance, wheelchair or walker, etc.

Although repetitive, recording trip details requires completeness and accuracy of the information since errors or omissions can lead to later problems in scheduling trips and routing vehicles. Eliciting sufficient information from the client can sometimes be a difficult and time-consuming task requiring substantial prompting from the reservationist. To assist in recording trip requests accurately, the reservationists may maintain a client registration file containing the names and addresses of regular callers to which reference may be made while speaking with the client.

Since virtually all telephone calls to the special transit office are answered by the reservationists, however, they must also respond to a wide variety of requests and inquiries. The job is a combination receptionist, information and public relations officer, complaint department, and clerk.

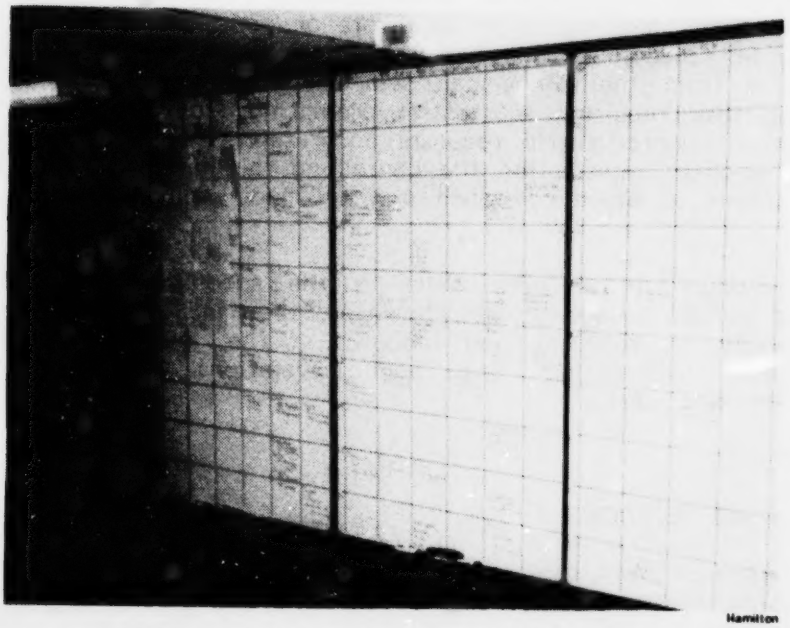
SCHEDULING SERVICES

The scheduling task for special transit services, as opposed to a conventional transit service, consists of matching requests for service with available vehicle resources. The scheduling of passengers consists of taking customers' requests for service and attempting to assign these requests to specific vehicles. The 'input' to this task is the set of origins, destinations, and desired delivery times associated with the service requests. The 'output' from the scheduling task is a set of vehicle schedules or runs consisting of a sequence of pickup and delivery stops, as well as expected arrival time for each stop.

Scheduling is a very complex and difficult task. It is usually either spatially or time-oriented. The map (spatial) system usually involves attaching trip tickets to pins or markers which are then placed on a large map of the service area near the actual pickup and dropoff addresses. Colour-coded markers may be attached to indicate vehicle assignments. Trip tickets are removed from the pins before dispatching and are arranged on a queue board by vehicle assignment and in dispatch order. In board (time-oriented) systems, trip cards or tickets are placed on a queue board or similar device as soon as they are scheduled.

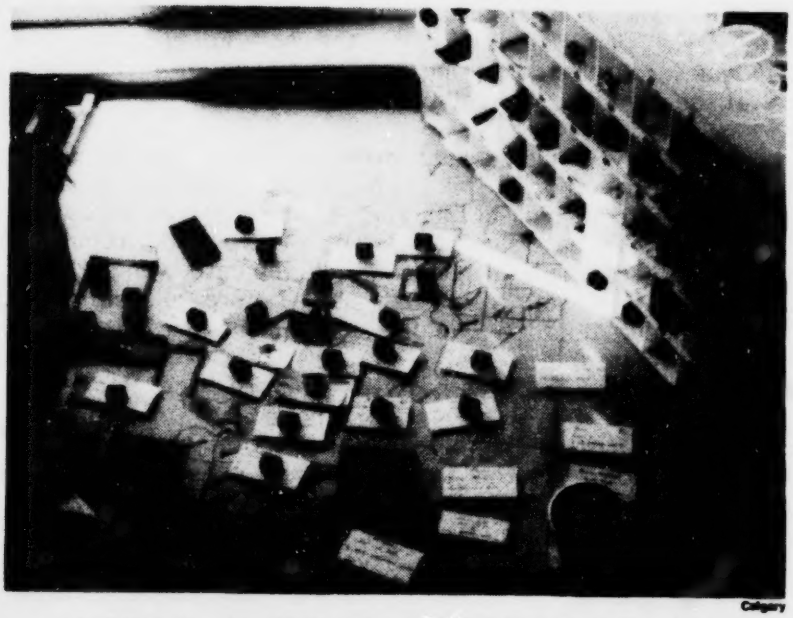
The time-oriented system is perhaps the more common in Canadian special transit services. In this system, large tables or boards are usually prepared -- one for each day -- with time in half hour segments down the side and vehicle runs across the top. Each cell of the table would contain a trip request and each row a vehicle run.

Under the map system, the scheduler has good spatial information because the current vehicle locations, the assigned service stops, and the



Hamilton

Exhibit 2: Time-Oriented Scheduling System



Calgary

Exhibit 3: Spatially-Oriented Scheduling System

unassigned demands are displayed in analog form. However, the system typically does not provide the scheduler with easily identifiable time information. The board system provides excellent time information; each vehicle run is arranged by time, giving the scheduler a view of promised pickup and insertion windows. Unfortunately, this system assumes the ability of the scheduler to maintain a service area map with vehicle locations and requested stops in his or her head. Even an experienced scheduler soon reaches a saturation point in the number of vehicle runs that can be handled.

Due to the inflexibility of these scheduling systems (and the fact that most of the trips are regular subscription trips), the general approach is usually to develop a 'master' schedule which would contain all the regular subscription trips for the service. This master schedule wouldn't change substantially from day to day. It would be copied or repeated into a 'current' schedule which would be used to develop the schedule for the current day. The advance reservation and daily demand trips would be placed into the current schedule if an opening is perceived in a cell that corresponds to the requested time and location.

Once scheduled, a request is rarely rescheduled to another run since it is difficult for the scheduler to constantly review all of the vehicle runs, looking for a better assignment of particular trips.

Another significant difference in scheduling methods is whether both the pickup and dropoff or just the pickup is scheduled. Some systems schedule both; others schedule only the pickup, leaving it up to the driver to decide on the order that the passengers would be let out at their destinations.

DISPATCHING VEHICLES

The primary task of the dispatcher is to transmit trip details and instructions to the drivers. The secondary task is that of monitoring the status of the vehicle fleet, transmitting schedule changes to the drivers, providing information to other office staff, and record-keeping.

The transmission of trip details and instructions to the drivers is a straight-forward task of communicating the details of the trip requests via the mobile radio to the vehicles on the road.

The dispatcher must also monitor the schedule to ensure that vehicles are running on time and, if not, take corrective action. If there is a significant departure from schedule, the dispatcher has to decide whether to use another vehicle for a particular trip or to dispatch a backup vehicle if it is available.

The dispatcher must also pay careful attention to cancellations or other alterations to the schedule since most of the service requests are for two-way trips and a schedule change for the initial trip may affect the return trip. As the overseer of the system operation, the dispatcher must also respond to inquiries from other office staff or management about the current position and status of the operation.

In operations where the dispatch and scheduling functions are separated, the dispatcher does not have a great deal of effect on the productivity of the service, only its punctuality and reliability. It is only when on-demand requests are being met that the dispatcher has a tremendous effect on the efficiency and effectiveness of the service.

PREPARING REPORTS

Special transit services are a very management-intensive business and a very large portion of the work performed by the operator is concerned with recording, sorting, retrieving, exchanging and displaying information. New information is recorded, files are updated, and records amended at a fairly high rate continuously throughout the day.

Trip requests and cancellations are usually recorded on small pieces of paper which are easily handled one at a time or bundled together for ease in passing them back and forth. Schedules are developed from the trip request files and vehicle run sheets are produced from the schedules. Driver trip logs are produced by each driver as the means of keeping track of the actual trips that took place.

All this information has to be reconciled at the end of each day and operating statistics and reports produced from the information. These reports are then used for monitoring operations.

The generation of operating statistics and reports is a cumbersome and labour-intensive job. It involves the manual manipulation of the data required, mainly from the driver trip logs, which is time-consuming and error-prone. The task is usually undertaken by the office staff with the supervisors keeping the monthly and yearly records of performance.

Usually, at least ridership, vehicle hours and vehicle kilometers, and revenue data is collected on a daily basis. Because the daily collection of other performance data is considered to be too time-consuming, the computation of valuable statistics such as average wait time, pickup time deviation, and average travel time may only be done periodically, if at all. Some operations do not keep track of individual pickup and dropoff times, so it would be impossible for them to compute meaningful trip-related performance statistics.

More interesting, with present systems, from an operational sense, is the lack of timely and appropriate management information reports and the necessary information required for planning purposes. It would naturally be desirable to have immediate status reports as well as management information reports. Management information and its use for planning purposes is probably the most important singular deficiency of most special transit service operations.

3. APPLICATIONS

Considerable interest and research efforts have gone into the application of computers to special transit services since 1967 -- much of this effort oriented towards the development of automatic scheduling systems. Procedures or algorithms for scheduling are conceptually the most difficult aspect of applying computers to demand-responsive services. The MIT/UMTA algorithms are undoubtedly the most sophisticated and complex algorithms to date. They have been under development since 1967 and have been tested in Haddonfield, New Jersey (1972-74) and Rochester, New York (1975-78). Similar algorithms are currently being developed and tested in Orange County, California, Dade County, Florida and Minneapolis, Minnesota. In Canada, an automatic scheduling algorithm has been recently developed at the Centre de recherche sur les transports at the Université de Montréal in a project funded by Transport Canada through the Transportation Development Centre.

The underlying design of the proposed Canadian computerized scheduling system features utmost flexibility, dynamic resource allocation and fully automated vehicle scheduling. Passenger insertion into a vehicle tour is effected dynamically by means of complex data manipulation algorithms which maximize vehicle occupancy rates and minimize passenger inconvenience. Its operational philosophy, unlike the systems being developed in the United States which preclude human participation in routine scheduling decisions, allows for manual manipulation of the resulting schedules.

Some opinion believes that, even if the algorithms were sufficiently developed, the desirability of human interaction with the computer is still

sufficiently strong that a completely automated system may not be the ultimate answer. Human dispatchers may always be able to take into account certain factors that a computer would not be able to. Therefore, in 1977, UMTA funded a series of contracts aimed at developing a computer-aided system that relied on some human intervention. The result was a graphical aid to schedulers (4). Shortly thereafter, in the early 1980s, various small properties began experimenting with the use of commercially-available data base management systems to provide computer assistance in the office with the belief that a management information system, rather than an information processing system, may be the solution to their problems.

As a result of these efforts, a wide range of roles have evolved for the computer, from the provision of rudimentary management information to the full automation of the entire reservation, scheduling and dispatching tasks. As will be readily apparent in the following review of the application of computers to special transit services in Canada, the appropriateness of any given role for the computer is highly dependent upon the size and nature of the special transit service.

TORONTO, ONTARIO

Wheel-Trans, the Toronto Transit Commission's transportation service for the physcially disabled, has grown from a pilot project serving 46 clients in the early 1970s to a highly-efficient computer-assisted service using a fleet of 62 buses and 24 station wagons providing more than 35,000 rides per month.

The 54-member Wheel-Trans department performs administration duties, order taking, scheduling, dispatching, and planning. A private contractor owns, operates and maintains the fleet of vehicles. Four basic services are offered to the 11,000 registered users. Advance bookings are taken up to seven days ahead for any trip purpose. The subscription service is a regular morning and afternoon rush-hour service for people on regular, predetermined schedules. A pre-booking service is available throughout the day to transport those with regular appointments two or three times a week for work, medical or educational purposes. Demand-responsive requests are taken for same-day service on the basis of availability.

The Toronto Transit Commission has long been interested in the application of computers to the problems of special transit services. In 1978, the TTC began entering information on registrants onto a computer file and periodically updated and modified the file. The file was accessed on the TTC's IBM 370-138 computer. The information was used to generate lists of registered users, mailing lists and statistics such as age and residential distributions of the disabled.

In the summer of 1980, the TTC began the process of redesigning its batch information system for Wheel-Trans so that data from driver run sheets and daily summary sheets could be entered into a computer. This was to allow the monthly reports to be prepared via the computer, rather than by the current manual methods. Both the input and output formats of the data and reports were redesigned to accommodate the current configuration of the Wheel-Trans service. This system used TTC data entry staff to input the information, and used the batch resources of a large IBM computer.

In May of 1980, the TTC, in conjunction with the Ontario Ministry of Transportation and Communications, engaged the University of Toronto and York University Joint Program in Transportation to conduct a study as to the feasibility of computer-aided scheduling for the Wheel-Trans system (1). Upon receipt in August 1980, the report was analyzed in detail by Commission staff, with the result that a proposal for a computer-aided scheduling system was developed which could be implemented in two phases. The first phase would incorporate an on-line reservation and information system, with the capability to display vehicle schedules, as they were being developed by the scheduler. The second phase would provide the computer with some decision-making capability for the scheduling task.

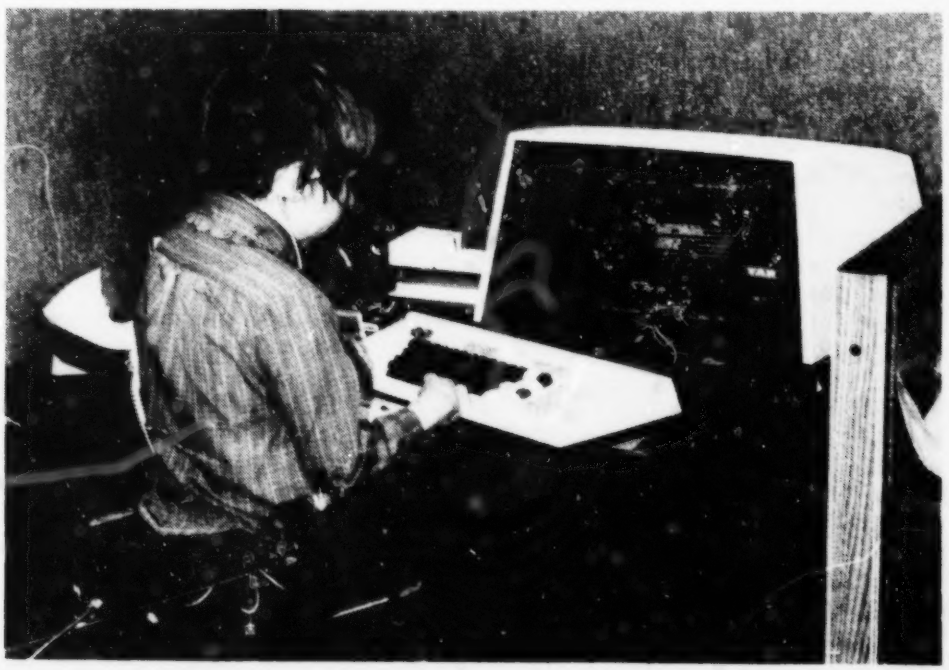


Exhibit 4: Computer-Aided Reservation in Toronto

A Request for Letters of Qualification was issued and responses were received in January 1982. Subsequently, general functional and physical requirements were developed and a request for proposals was issued to a few selected system suppliers in May 1982. Following the submission of proposals, GIRO was awarded the project in late 1982. The first part of the work, which included both hardware design and a software design, began in February 1983 and a functional design document (5) was released in October 1983.

GIRO had originally anticipated developing the software for the Wheel-Trans project from software developed by Transmax in the United States. Transmax, under the sponsorship of the Urban Mass Transportation Administration, had developed computer-assisted scheduling and dispatching software which was being tested in Dade County in Florida. Difficulties in obtaining the software, however, were experienced and GIRO has had to develop much of the software -- causing a delay in the planned implementation date. The first part of the system, client registration and trip reservation, began operation in October 1984 when a Prime 550 computer system was installed. This initial phase of the system reduces paper flow and errors in manual transcription, enabling the staff to store, retrieve, and update information more quickly and accurately. From the registration and reservation information stored in the computer, trip tickets are produced which are used with scheduling boards in a manual scheduling process.

Currently, work is being undertaken on developing scheduling aids that can be accessed with the computer. The proposed system, which is to be completed by the end of 1985, will not automatically build vehicle runs; it will, however, include a series of aids to facilitate the scheduling process. A route suggestion algorithm is proposed that will take into account several factors including vehicle type and capacity, operating hours, availability and location based on trips already scheduled. This algorithm will suggest a list of the most probable vehicles available to meet a particular trip request. The computer screen will become a scheduling board, permitting rapid manipulation of information without manual recopying.

The GIRO system is also designed to permit the use of automatic scheduling algorithms, which could be used to quickly produce a 'first-cut' schedule. This schedule could then be verified and modified if necessary by the transit service's staff. Such algorithms have been recently completed by the University of Montreal's Transportation Research Centre under a grant from Transport Canada. The TTC, in their original systems design, had anticipated using an automatic scheduling algorithm at a later date but this date is yet to be specified. The next phase of the project will include a schedule optimization function and the final phase will include post-optimization features for fine-tuning the schedule. The total project budget is $540,000 (6).

MONTREAL, QUEBEC

The Commission de Transport de la Communaute urbaine de Montreal (MUCTC) is responsible for providing transit services for the disabled in the Montreal urban community and suburbs, serving an area of 190 square miles and a population of over 2 million.

The system carries upwards of 1000 persons per day on 46 vehicles and a number of taxis. Approximately 6000 individuals are registered users of the service. Total staff employed is 104, including 87 drivers and 17 office staff.

Subscription trips account for about 40 percent of the total trips and the other 60 percent are advance reservation trips which may be requested by clients up to 48 hours in advance of the service.

In April 1984, the MUCTC retained GIRO to implement a computer-aided scheduling system on their IBM 4381, a large mainframe computer. The system is essentially the same as Toronto's system except that scheduling for advanced trips is to be done while the client is on the phone.

The initial aspects of the system, including client registration and trip reservation, were installed in February 1985 and 15 terminals were made available to the special transit service operator for these functions. The trip insertion algorithms and scheduling aids are to be in place by the end of 1985. The MUCTC currently has no plans to proceed with the automatic scheduling algorithms that Toronto is planning to use.

SHERBROOKE, QUEBEC

The Corporation metropolitan de transport Sherbrooke (CMTS) is the provider of transit services for the disabled in Sherbrooke, Quebec and the surrounding area. Serving an area of 55 square miles with a population of 110,000, the system operates seven days a week from 7:00 am until midnight. Approximately 160 trips per day are served with seven vehicles. The total staff is 11, including eight drivers, two dispatchers and a supervisor.

Of the approximately 56,000 trips that are served each year, 41 percent are served with taxis. The average cost per person trip on the taxi service is estimated at $2.59 while the average cost per person trip on the minibus service is estimated at $12.61 (operating cost only). Each taxi trip carries an average of about 3.0 persons. The CMTS has therefore realized a significant cost advantage in using taxis as a complementary service and plans to use them to absorb anticipated increases in ridership.

GIRO recently signed a contract with Sherbrooke to provide their computer-aided management information system, Acces, on an IBM PC/AT for the transit service operator. Work began in the spring of 1985 and was essentially complete by August. This included the computerization of the client registration and trip reservation functions and the production of trip tickets that can be used in a manual scheduling process. The rest of the initial phase of the GIRO/Acces system is planned for implementation in October 1985. The budget for the project is about $35,000 for software and $15,000 for hardware.

The proposed system is essentially a computer-aided scheduling tool that provides suggestions for entering a trip into a previously established schedule (7). The algorithm for inserting trips into a schedule uses travel times between zones to establish time windows into which a trip can be inserted. In Sherbrooke, the zones are about one mile square (25 zones in all). Seven master schedules can be defined that describe regular runs and regular subscription trips. These master schedules are used to initialize current schedules for a particular date. Advance reservations and demand-responsive trips are then added to the appropriate schedule using the trip insertion algorithms which are currently being tested.

QUEBEC CITY, QUEBEC

Transport adapte du Quebec Metro Inc. (TAQM) is the provider of transportation services for the disabled in Quebec City and suburbs. The system carries approximately 300 people per day in 6 vehicles and has a staff of 24 which includes 11 drivers.

In November 1983, Systemoid Incorporated was asked to design an information system for TAQM and a preliminary study was undertaken of a computer-based information system to support the operations, management and decision-making activities of the organization. Operational activities consisted of client registration, trip reservation and trip scheduling. Managerial activities were related to personnel, fleet management, accounting and work scheduling. Decision-making activities were concerned with report generation, registration of new clients, employee hiring and new vehicle purchasing.

This six-week preliminary study resulted in a proposal to introduce a computer-based system to TAQM's operations in several phases. The first phase was to register on the computer some information about potential clients (admissions as well as rejections) in order to ensure that if a rejected client reapplied at a later date, their record would be available. The information on admitted clients would be used to verify and simplify the later capturing of trip reservation data. The second phase was to implement scheduling aids using a data base management system. To

prepare a schedule, the scheduler would query the data base, requesting such information as: trip request time, departure address, destination address, etc. Using this information, the schedule could be prepared and the data base updated with the schedule information. Standard reports could also be prepared from the data base for decision-making.

After the initial study, TAQM awarded a contract to Systemoid to implement the first phase of the project. A data base management system and fourth generation language were selected, a detailed study was completed and the implementation phase was undertaken (8). This phase consisted of developing the system to support the operations of TAQM in client registration, trip reservation, trip scheduling and report generation. This phase was completed in September 1984 at a cost of about $25,000 excluding hardware and commercial software. All the modules were developed using database management tools and fourth generation language purchased by TAQM. These permitted the creation, querying, updating and deleting of the data in the data base in an interactive fashion.

OTTAWA, ONTARIO

The Ottawa Carleton Regional Transit Commission (OC Transpo) is responsible for providing conventional and special transit services in Ottawa. M & O Bus Lines, under contract to OC Transpo, has been the provider of the service for the disabled in the region for many years. The system presently carries 500 trips per day using an 18 vehicle fleet. Due to the high proportion of demand-responsive trips (33%) which require immediate scheduling and confirmation, the order-taker schedules trip requests into available time slots as they are received. The office staff, at its peak period, consists of two order-takers and a dispatcher.

To help keep track of subscription (35%) and reservation (32%) trips, the contractor in Ottawa began the custom design and implementation of a computer system in the fall of 1979. Canada Systems Group (CSG) was subsequently retained by OC Transpo and a functional system design document was produced in December 1982 (9). The system was essentially operational by January 1983 although acceptance testing wasn't completed until June 1983.

The system was designed to be used by the order-takers to directly enter subscription and reservation requests onto the appropriate vehicle run. The scheduling task of choosing the appropriate vehicle and selection of the scheduled time of pickup was to still be handled manually by the order-taker. At the end of the day, the computer system was to be used to generate the driver run sheets for the following day's trips. These lists would be distributed to the drivers of the vehicles and to the dispatcher.

The same-day requests for service, rather than being scheduled by the order-taker, were passed on directly to the dispatcher. The dispatcher, using the complete set of printed driver runs for that day, tries to schedule the demand response trips into available time slots and relay the pertinent information to the selected vehicles. The information on the demand responsive trips is put aside until the end of the day, when they are entered into the computer to enable the complete statistics for the day to be generated (10).

Although the system was operational for about a year, it was plagued with system problems and tended to crash when users attempted to access certain functions or files at the same time. Therefore, the system was not operational for about one year. The system problems were eventually remedied and initial operation and testing began again in June 1985. Currently, only the client registration function of the system is being used. OC Transpo is planning to have the full system in operation in October 1985. The budget for the system implementation was not available.

EDMONTON, ALBERTA

The Disabled Adult Transportation System (DATS), Edmonton's transportation service for the disabled is administered by the City's Transportation Department. DATS currently provides approximately 1100 trips per day with about 45 vehicles to 6890 active registered users, approximately 45 percent of which are in wheelchairs. About 35 percent of the trips are subscription trips, 35 percent are demand trips, with the rest being advance reservation and prebook trips. Service is offered seven days a week from 6:00 am until midnight.

In 1981, D.W. Ellis & Associates Limited was retained by Edmonton Transit to perform a feasibility study on the automation of the process of routing and scheduling of the Disabled Adult Transportation System (DATS) vehicles. The feasibility study led to the development of the DATS Scheduling System. The System was developed and implemented over a twenty-month period between December 1981 and August 1983 in three stages. The first stage was the development of a computer support system for the existing manual registration, monitoring and scheduling procedures. The second stage was the development of features to allow computerized scheduling of single trips into existing schedules. The inclusion of the ability to schedule a day's routes to ensure more efficient service and vehicle usage was included in the third stage.

The first part of the first stage, the computerization of the client registration process, was implemented in late 1981. The rest of the first stage was implemented between then and April 1982. After some minor

changes, the first stage system has remained unchanged. The second stage was implemented in May 1983 and the third stage was completed in August 1983 (11). The total cost of the system development effort was approximately $375,000 for the software and $300,000 for the hardware.

The implementation of the DATS Scheduling System on the Edmonton Transit's Hewlett Packard 3000 Series III computer initiated a period of intense interest in transportation services for the disabled. The central element of the system was a scheduling algorithm for inserting trips into a series of routes and schedules that were already developed. This scheduling algorithm is probably one of the first fairly successful attempts at addressing the routing and scheduling problem of these services using time windows to ensure compliance with operating policies. The time windows define a specific time interval or envelope into which trips can be inserted without violating other operating policies or parameters.

The system, because of its design, has a number of deficiencies that are difficult to correct. These deficiencies include questions relating to the logic of the algorithm, poor time-responsiveness and limited capabilities for report generation. Manual procedures were implemented by the users to compensate for the deficiencies and these have tended to adversely affect the overall efficiency of the service (12). Due to the system design and operational deficiencies, as well a desire to obtain more current and up-to-date hardware, consideration is being given to phasing out the system in the near future. A jointly-sponsored project with the Transportation Development Centre was begun in the summer of 1985 with the intention of investigating a centralized computerized scheduling and brokerage system.

HAMILTON, ONTARIO

The Disabled and Aged Regional Transit System (DARTS) is a non-profit agency providing transportation service to the disabled and elderly in the Regional Municipality of Hamilton-Wentworth. Approximately 700 trips are provided daily to 3500 registered users with 21 buses and a number of taxis. About 40 percent of the trips are regular subscription trips and 60 percent are advance reservation trips which may be booked at any time.

DARTS had been using a computer since 1983 to perform some client registration, reservation and management reporting functions using a common database management program, dBase II, operating on an IBM Personal Computer. As the size of the system grew, so did the needs for faster and more efficient computer software. After looking at the possibilities of using dBase III, DARTS decided to retain a computer consultant, Comshare Limited, to completely rewrite the software so that it would be faster and more efficient.

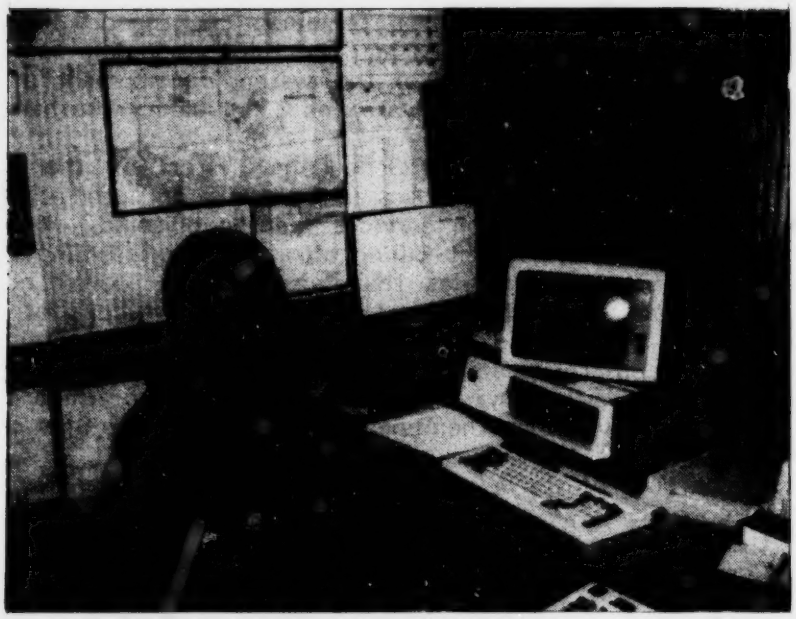


Exhibit 5: Computer-Aided Scheduling in Hamilton

The present system operates on an IBM PC/XT and provides client registration, trip reservation, computer-aided scheduling and management reporting functions (13). The software uses a multi-user operating system called QNX and is developed from a data base management system called ZIM. The operating system also provides micro to micro and micro to mainframe communications. After the trips are scheduled and vehicle numbers assigned to each trip, the system will sort and insert about 300 trips automatically into the master schedule in about 20 minutes. The system was installed in June 1985 and has been operational since then with few problems. The total cost of the system implementation, including hardware, was about $40,000.

The reservationist, while the client is on the phone, enters the trip booking information directly into the computer. The system also assists the scheduler in assigning vehicles to trips by sorting and presenting the daily trip reservations in order of time. After the vehicle numbers are assigned, driver trip sheets and taxi trips can be printed out. Monthly statistics are also provided to allow management to analyze the performance of the operation and to aid in invoicing agencies that subsidize some of the clients' trips.

The database consists of four main files. The client file contains information on each of the registered clients such as identification

number, address, and most frequent destinations. The second file, the booking file, contains all the irregular bookings that the clients have requested. The master schedule file is the third file and it contains all the regular subscription bookings for clients. The fourth file is the current schedule (or today) file containing all the requested trips for the current day.

In summary, a booking is entered into the computer by the reservationist and is stored there until the day prior to the trip. It is then printed on a booking list and is assigned a route number by the scheduler. This route or schedule number is input into the system and the booking is then printed on the appropriate driver's list. It is also stored on the current day's bookings set where it can be modified in the event of a cancellation or no show. The booking is then posted to a statistics record which is used to provide the monthly accounting and statistics reports.

VICTORIA, BRITISH COLUMBIA

Early in 1983, BC Transit began to explore the feasibility of installing a computer in the Victoria custom transit operation to assist in organizing passenger and trip records. A Victoria firm that had experience in the design and development of similar software was contracted to design the custom transit software. BC Transit, in consultation with Dialog Business Computer Systems Limited and the operating company, Accessible Transportation Alternatives Limited, developed the functional specifications.

The system was implemented in the Victoria office in September 1983 and has contributed to a number of administrative and service improvements. The same system was implemented in a second custom transit office in Kamloops, British Columbia in March 1985.

The hardware acquired for the Victoria operation included an Onyx multi-user microcomputer, two monitors and keyboards, and a dot matrix printer. The Onyx consists of 128Kb RAM, 6.7Mb Winchester disk and a 10Mb streaming tape cartridge for backup. The Onyx was selected primarily for the multi-user operating system, Oasis, which was available with the Onyx. All programming was done using the Cobol language. The total cost of this two-user system was $19,000 for the hardware and $41,000 for the software (this cost includes BC Transit staff time in addition to the software development costs).

As originally implemented in Victoria, the system stored 1,300 clients and approximately 300 regularly-scheduled and advance-booked trips. Since then, file sizes have more than doubled and additional memory has been installed. As well, the Oasis operating system has been upgraded (14).

The software in use in the Victoria system is the product of a number of sources of information. Many of the concepts and definitions were adapted from other systems. For example, the registration file is similar to that developed for the Ottawa system. Other aspects of the system were adopted from a doctors' scheduling package developed by Dialog. The majority of the specifications for the software, however, were developed by BC Transit and the operating company in conjunction with the consultant to meet the criteria set out for the special transit operation in Victoria.

The software development went through three phases. The initial package was implemented in September 1983. It included the primary client registration and trip statistics files. Minor modifications to these programs and the trip statistics programs were added early in 1984. In June 1984, the software package was updated to provide the ability to print trip tickets and mailing labels. As well, the ability to print summary information on clients by zone and disability was added. A major design change which permitted the entry of more than one vehicle number in a trip record was accomplished. Prior to this change, a client travelling five days per week at the same time to and from the same locations but on a different vehicle each day, had to be booked in five different trip records. The total cost of software development, including modifications was about $10,000.

Exhibit 6: Computer-Aided Reservation in British Columbia

The Victoria computer system precipitated a 35 percent increase in the productivity of the service. Over the eighteen month period from September 1983 to March 1985, the number of rides per hour increased from 2.0 to 2.6. The 11,000 additional trips provided at the higher productivity level would have required more than 6,000 hours of service at an annual cost of about $150,000.

The installation of a computer in the Victoria custom transit office has resulted in a restructuring of the way in which information is processed. It has provided the operator with the capability of merging information from numerous files to aid in the production of efficient vehicle schedules.

While scheduling of trips remains entirely a manual procedure, the arrangement of the information that is available has influenced the operator's approach to the process. Trip sheets, that were previously scheduled based on thirty-minute time slots as defined by the scheduling boards, have been restructured on a variable basis. This new approach, while not directly attributable to the computer, is one of the side benefits that have been realized.

The computer has also contributed to simplifying the job of training new schedulers. The experience in Victoria and Kamloops has shown that it takes less than a week to become competent in using the software. The logical manner in which the information is organized has helped to reduce the complexity of the scheduling process.

SUMMARY OF CANADIAN SYSTEMS

A consolidated summary of computer applications to special transit services in Canada is presented in Exhibit 7 on the following page. The operational environment, hardware configuration, software features, development timing and approximate costs of each application are provided in the exhibit.

A wide variety of hardware and software configurations have been developed over the last couple of years in an attempt to solve the scheduling and dispatching problems of special transit services. The computer applications, however, appear to have similar broad capabilities in the areas of client registration, trip reservation and report generation.

Although the capabilities may appear fairly similar, the costs and effort involved in their development vary considerably -- from about $50,000 for a computer-aided scheduling system to over $800,000. Although large minicomputers have been used for some systems, several of the newer systems are making use of relatively inexpensive microcomputers such as

Exhibit 7: Computer Applications to Special Transit Services

		Toronto, Ontario	Montreal, Quebec	Sherbrooke, Quebec
System Environment	Registered Clients	12,000+	6,000	600
	Number of Vehicles	85+	46 (plus taxis)	7 (plus taxis)
	Number of Drivers	120	87	8
	Number of Staff	54 total office staff 11 order-takers 16 schedulers 10 dispatchers 17 other staff	17 total office staff	3 total office staff 2 dispatchers 1 supervisor
	Number of Trips	1800 per day 45% subscription 45% advance 10% immediate	1000 per day 40% subscription 60% advance	160 per day
System Configuration	Computer	PRIME 550	IBM 4381	IBM PC/AT
	Memory	2,000 Kb	16 Mb	640 Kb
	Drives	2-300 Mb 1-80 Mb	900 Mb	
	Terminals	30+ terminals	15 terminals (supports 300)	none
	Printers	2 printers	3 printers	1 printer
	Communications	Gandalf multiplexor for remote terminals	CICS/VS	
Applications Software	Functions	Client Registration Trip Reservation Scheduling Assistance Dispatching Monitoring	Client Registration Trip Reservation Scheduling Assistance Dispatching Monitoring	Client Registration Trip Reservation Scheduling Assistance Dispatching Monitoring
	Files	Client Common Address Trip Request Log Scheduled Trips Run Descriptions Geocode System Zone-to-Zone Times Transaction File Dispatch Files	Client Common Address Trip Request Log Scheduled Trips Run Descriptions Geocode System Zone-to-Zone Time Transaction File Dispatch Files	Client Common Address Trip Request Log Scheduled Trips Run Descriptions Geocode System Zone-to-Zone Times Transaction File Dispatch Files
	Processes	Prints trip tickets which are used in a manual scheduling process at the present time. Proposed trip insertion algorithm.	Will display vehicle runs and trip requests for manual or automatic trip insertion into a master schedule.	Will display vehicle runs and trip requests for manual or automatic trip insertion into a master schedule.
	Language	COBOL	COBOL	COBOL
	Developer	GIRO Incorporated	GIRO Incorporated	GIRO Incorporated
Systems Software	Functions	Sort and other utilities Transfer to backup computer	Sort and other utilities	Sort and other utilities
	Programs	PRIMENET	TOP/SECRET CICS/VS USAM	Microsoft Sort Microsoft COBOL Compiler
	Operating System	PRIMOS	OS/VMS	IBM MS-DOS
Implementation	Initiation Date	February 1983	April 1984	June 1985
	Initial Startup Date	October 1984	February 1985	August 1985
	2nd Stage Startup	December 1985	December 1985	October 1985
	Overall Timing	24 months	18 months	4 months
System Costs	Computer Costs	$300,000 est.	n/a	$15,000
	Software Costs	$540,000	n/a	$35,000
	Total System Costs	$840,000	n/a	$50,000

Quebec City, Quebec	Ottawa, Ontario	Edmonton, Alberta	Hamilton, Ontario	Victoria, British Columbia
1,100 clients	8,000 clients	8,890 clients	3,500 clients	2,500 clients
7 (plus taxis)	38 vehicles	45 vehicles	21 (plus taxis)	10 (plus taxis)
11	n/a	40 (20 part-time)	11 (22 part-time)	12 (2 part-time)
13 total office staff	5 total office staff 2 order-takers 1 scheduler 1 dispatcher 1 supervisor	13 total office staff 4 order-takers 1 scheduler 3 dispatchers 5 other staff	11 total office staff 1 order-taker 1 scheduler 2 dispatchers 7 other staff	3 total office staff 2 order-takers/schedulers/ dispatchers 1 supervisor
300 per day	850 per day 25% subscription 40% advance 35% immediate	1100 per day 35% subscription 30% advance 35% immediate	700 per day 40% subscription 60% advance or immediate	250 per day 55% subscription 30% advance 15% immediate
DEC VAX-11/750	DEC VAX-11/730	HP 3000 Series III	IBM PC/XT	ONYX (IBM PC/XT*)
4,000 Kb	3,000 Kb	1536 Kb	640 Kb	192 Kb
2-456 Mb Drives	121-Mb Drive	2-132 Mb Drives	1-10Mb Fixed Disk 1-360Kb Floppy Disk	1-6Mb Winchester
2 DEC VT-220's	5 DEC VT-220's	5 terminals	5-ESP 6310 semi-intelligent terminals	2-Terminals
1 printer	1 DEC LA100	1 printer	1-HP Thinkjet	1-Okidata Dot Matrix
Gandalf multiplexor for remote terminals			Hayes Smartmodem for remote support	
Client Registration Trip Reservation Scheduling Assistance Dispatching Monitoring	Client Registration Trip Reservation Scheduling Assistance Dispatching Monitoring	Client Registration Trip Reservation Automatic Scheduling Dispatching	Client Registration Trip Reservation Scheduling Assistance Dispatching (run sheets) Monitoring	Client Registration Trip Reservation Trip Tickets/Mailing Labels Dispatching (run sheets) Vehicle Statistics
Client Master File Trip Master File	Client Master File Trip Request File Trip List File	Registrant File Trip Request File Travel Time File Parameter File	Client Master File Trip Booking File Master Schedule File Client Statistics File Monthly Statistics File Transaction File	Client Control File Client Master File Trip Master File Disability Code File Zone Code File Vehicle Master File Daily Transaction File
Uses various sorting functions of database management program to assist the scheduler	Prints out a daily trip list ordered by time and location to assist the scheduler in assigning trips to runs.	Uses a trip addition algorithm to insert a trip into the master schedule.	Prints out a daily trip list ordered by time to assist the scheduler in assigning vehicle run numbers.	Prints out individual trip tickets that can be used in scheduling boards. Prints run sheets and keep statistics.
POWERHOUSE	PASCAL	FORTRAN	ZIM Data Base Manager	COBOL
Systemoid Incorporated	Canada Systems Group	D.W. Ellis & Associates	Comshare Limited	Dialog Business Systems
DataBase Management Fouth Gen'tion Language	DataBase Management Forms Management	Database Management Sorting and Merging File Editing	None	None
POWERHOUSE	DBMS-32 FMS DATATRIEVE	EDIT, SORT-MERGE, QUERY, FCOPY, IMAGE HP DICTIONARY	None	RM COBOL Compiler
VAX/VMS	VAX/VMS	HP MPE	QNX	OASIS (DOS*)
November 1983	October 1979	July 1981	February 1985	February 1983
February 1985	January 1983	December 1981	June 1985	September 1983
n/a	October 1985	August 1983	n/a	February 1984
13 months	24 months	20 months	5 months	12 months
$12,000 (rental)	n/a	$200,000 est.	$15,000	$19,000
$25,000	n/a	$375,000	$40,000	$41,000 (incl. staff costs)
$37,000	n/a	$575,000	$65,000	$60,000 (incl. staff costs)

*put on IBM PC/XT in Kamloops in March 1985

the IBM PC/AT. In Sherbrooke, for example, the GIRO/Acces system which was developed for Toronto on a minicomputer is being downloaded to operate on a personal computer. In British Columbia, the system developed on the Onyx minicomputer was also downloaded to a personal computer.

These trends will tend to make computer-aided scheduling systems for special transit services more affordable and more accessible for smaller transit operators. The major difficulty will then be in finding the software that has the desired features and performs the desired functions.

4. FUNCTIONS

Computer-aided client registration, trip reservation and report generation for special transit services for the disabled is not new -- as seen in the previous chapter, many operators have been using computer systems for years -- but the computer and software applications are certainly becoming more popular. Early developments in this area were fraught with problems and all were custom-developed for specific client organizations.

The use of computers in special transit services can certainly yield benefits. The systems reduce paper flow and errors in manual transcription and they enable the operator to store, retrieve and update information more quickly and accurately. Although the major benefits to date have been related to a decrease in human errors, staff turnover and training time, passengers generally gain a number of benefits including better and more dependable service and staff gain through reduced stress, fatigue and routine work load. Finally, community good will is generated -- an intangible benefit that comes from citizens believing that governmental agencies are responding to their needs.

All of the systems perform (or are planned to perform) client registration, trip reservation and report generation functions and use this information in the validation of trip requests or to lessen the amount of information that is collected in the trip reservation process (see Exhibit 8).

In this chapter, the functions of the various computer applications are described. A function is the general term for a defineable set of activities undertaken in the offices of an operator of special transit services.

FUNCTIONS		BC Transit DART	CSG ParaTranspo	GIRO Acces	Comshare DARTS	Ellis DATS	Systemoid TAQM
REGISTRATION	enter and update client data	●	●	●	●	●	●
	generates next registrant number	●	●	●	●	●	●
	find client using registrant no.	●	●	●	●	●	●
	find client using last name	●	●	●	●	●	●
	permits deregistration of clients	●	●	●	●	○	●
	deletes temporary clients	●	●	●	○	○	●
	checks for duplicate registrations	○	●	●	●	○	●
	allows for suspension of clients	○	●	●	○	○	○
	detects inactive clients	●	●	●	●	○	○
	displays/prints client statistics	○	●	●	●	○	●
	prints identification cards	○	○	◒	○	○	○
	generates mailing labels	●	○	◒	●	●	●
RESERVATION	enter and update trip requests	●	◒	●	●	●	●
	on-line verification of eligibility	●	◒	●	●	●	●
	on-line verification of address	●	◒	●	●	●	●
	displays registrant's trip requests	●	◒	●	●	●	●
	checks for duplicate bookings	○	○	●	●	○	○
	handles trip cancellations	●	◒	●	●	●	●
	responds to requests for status	●	◒	●	●	●	●
	data entry checking procedures	●	◒	●	●	●	●
	keeps list of common trips	○	◒	●	●	○	●
	keeps list of common addresses	○	◒	●	●	●	●
	coded value for origin of trip	●	◒	●	●	○	●
	uses code for common trips	○	◒	●	●	○	●
	codes for common destinations	○	◒	●	●	●	●
	default values for return trip	●	◒	●	●	●	○
	trip request file access by client	●	◒	●	●	●	●
	trip request file access by date	○	◒	●	●	●	●
SCHEDULING	enter and update vehicle runs	○	◒	◒	●	●	○
	retrieves trips by day and type	○	◒	◒	●	●	●
	sorts trips by time and location	○	◒	◒	●	○	●
	prints trip request list by time	○	◒	◒	●	●	●
	prints individual trip tickets	●	○	●	○	○	●
	trips assigned manually to runs	●	◒	●	●	○	●
	displays vehicle runs on screen	○	◒	◒	●	●	●
	allows trip insertion on screen	○	○	◒	●	●	○
	automatic trip insertion in runs	○	○	◒	○	●	○
	can insert/delete trips from runs	●	◒	◒	●	●	○
	tracks vehicle seating capacities	○	◒	◒	●	●	○
DISPATCHING	orders trips by run and time	●	◒	◒	●	●	○
	produces driver run sheets	●	◒	◒	●	●	○
	daily trip lists for dispatcher	○	◒	◒	●	●	●
	tracks location/status of vehicles	○	○	○	○	○	○
	can update trip status on-line	○	◒	◒	○	○	○
MONITORING	enter and update actual trip data	●	◒	○	●	○	●
	reconciliation with driver run sheets	●	◒	○	●	○	○
	records no-shows, cancellations	○	◒	◒	●	○	●
	confirms fare receipts from drivers	●	◒	○	●	○	○
	maintains actual trip log file	●	◒	◒	●	○	○
	maintains client travel history file	○	◒	◒	○	○	●
	maintains vehicle trip history file	●	○	○	○	○	○
	prepares client trip reports	○	○	○	○	○	○
	prepares client/agency billings	○	○	○	●	○	○
	prepares operating reports	●	◒	◒	●	○	●
	prepares financial reports	○	◒	◒	●	○	○

● - operational ◒ - being tested

Exhibit 8: Functional Comparison

CLIENT REGISTRATION

The first function begins when a potential client requests permission for service from the operator. Usually some type of screening process is performed to determine the eligibility of the applicant. If it is determined that the applicant is eligible for service, the client will be registered on the computer.

The client registration function should allow easy registration of new clients, deletion of inactive clients, check for duplicates on file, and provide lists of new registrants and change activity. It should allow search of the file by client name, registration number or, possibly, telephone number.

Accessing a Client

A sequentially-assigned client number is used by all the systems to access the client's file. Access by name is also possible with the systems; in case of duplicate names, the GIRO/Acces system provides a list of possible choices while other systems, including the BC Transit/DART and Comshare/DARTS, use a key to scroll through the list in alphabetical order one at a time. In the CSG/ParaTranspo system, the clients initials must be entered where there are duplicate last names. In the Ellis/DATS system, a list of possible choices is provided; then the correct choice is accessed with the registration number. Partial keys are also possible with the GIRO/Acces system, for example, by entering 'T' in the name field, all clients having a last name starting with 'T' will be listed.

Entering Information

In all the systems, the necessary information on each eligible client is entered into the system by filling in a form that is put on a video display by the computer. The information collected normally includes specific data on the client such as name, address and telephone number, as well as general information to assist the drivers in serving the client such as disability, age and sex. All of this information goes into a client file of registered users.

Both the CSG/ParaTranspo and Comshare/DARTS systems allow for the entry of three common destinations for the client which are used in the trip reservation function to reduce the amount of information that has to be keyed in for each trip request. The GIRO/Acces system automatically keeps track of the most common destinations in the last three months.

The GIRO/Acces system provides the possibility of indicating expiry dates for eligibility, as well as temporary suspensions. Seasonal eligibility (winter only) can also be defined. The CSG/ParaTranspo system indicates registration expiry dates and also allows for holiday periods in a regular

subscription booking. The Ellis/DATS system keeps track of holiday periods for regular subscription users; however, it was found that this function was rarely used in Edmonton. The GIRO/Acces system on the other hand has found this feature to be used regularly. All systems, except the Comshare/DARTS and Systemoid/TAQM, allow for the entry of a registration expiry date so that temporary clients can be registered.

Only the GIRO/Acces and CSG/ParaTranspo systems aggregate client usage data against the client file automatically and display it on the screen so that the operator can see the number of trips, no shows, cancellations and so forth that each individual client has taken over a certain period of time.

Deleting a Client

Deregistration of clients on some systems is difficult. The Ellis/DATS system, for example, required the development of a separate program to assist in noting 'active' clients and deleting inactive clients. Comshare/ DARTS will only allow deletion of a client if no statistics or bookings are associated with the record. Most systems 'flag' the record and delete it at the end of the year when all the statistics have been recorded. Since the BC Transit/DART system aggregates statisitics against a vehicle file, rather than a client file, clients can be deleted at any time.

Auditing the File

Each time a client's file is modified in the GIRO/Acces, Ellis/DATS and the CSG/ParaTranspo systems, the update time and date is recorded on the file. A 'history' or 'transaction' file logs the operator identification of the person who made the change. If desired, a printed record of all changes is available. The BC Transit/DART system does not provide a transaction log but it does record the date of the most recent changes to a client record.

TRIP RESERVATION

Unlike the manual system where the call-taker fills out a request slip, a computerized system allows the order input process to be carried out by directly keying in all relevant passenger information into the computer.

In almost all systems, each order-entry clerk is equipped with a video display terminal and is guided by the system to collect all necessary information about the client and the service desired. The following information is usually collected for each request: client number, client name, pickup address, destination address, number of ambulatory and wheelchair positions required, requested day and time, trip category, etc.

The reservationist should be queried by the computer for this information to ensure that all of it is recorded. In addition, the customer's recent trip information from previous requests should be displayed to allow the reservationist to simply modify information in a previous request to meet the requirements of the current request.

Entering Information

Much of the information is filled in by the computer using the information on file for the client, including their home address. The description of trips taken in the last three months is stored on the computer in the GIRO/Acces system and can be re-used when entering a new request by simply modifying the request time, the day, and the number of escorts. On the CSG/ParaTranspo and Comshare/DARTS systems, up to three destination addresses may be entered into the client registration file and referenced by a numerical code for entering destination data during the trip reservation function. All systems, including the Ellis/DATS, Comshare/DARTS and BC Transit/DART systems, have the ability to use the information from the originating trip for the return trip. Usually, only the time of the return trip has to be specified -- the locations are derived from the originating trip.

The GIRO/Acces, CSG/ParaTranspo and Ellis/DATS systems keep a common address file that allows the operator to use simple codes to input common destination addresses for trips. All the systems also use special codes for type of disability and special equipment required by the user.

Checking the Data

Since the systems display the client information on the top half of the screen with the trip information in the middle or bottom half, they provide the operator with the ability to check the client's eligibility, personal and locational information on-line. This reduces the amount of information that has to be solicited over the phone when the reservationist is taking a trip request.

A number is assigned to each trip, and if an identical trip is reserved twice in the same schedule, the GIRO/Acces system advises the operator who can determine if the second reservation is an error, a duplicate request, or a legitimate modification to a previous request. This feature is very useful in eliminating double and/or conflicting bookings.

Handling of Trips

The systems are usually geared to distinguish between subscription, advance reservation and on-demand requests for service. The GIRO/Acces system also provides for a special type of demand-responsive request, the return trip, which is used for clients who could not give their return time

when they made their original booking. On the CSG/ParaTranspo system, both demand-responsive and return trips are handled separately, although currently the only demand-responsive trips permitted operationally are return trips.

Up to five clients can be registered on the GIRO/Acces system on a single trip request if they are travelling together from the same departure point to the same destination. These 'accompaniers' must also be registered clients. Escorts, however, do not need to be registered clients. The Comshare/DARTS system does not record the number of passengers on each individual trip.

Since trips can easily be aggregated against the day of service, it is possible to return immediate positive or conditional confirmation to requests depending upon the priority of the service desired and the capacity still available at the time of the request with both the GIRO/Acces and CSG/ParaTranspo systems.

An interesting feature of the Comshare/DARTS system is the ability to cancel a number of trips at the same time for a particular program closure. All trips with a matching destination to the address where the program is being held will be cancelled at the same time for a specified day or period.

Listing the Trips

Each reservation in the CSG/ParaTranspo, Comshare/DARTS, Ellis/DATS and Systemoid/TAQM systems can be sorted by time and location and printed out in a list that is used by the scheduler to assign vehicle run numbers to each trip in the scheduling process.

Each reservation in the GIRO/Acces and the BC Transit/DART systems gives rise to the printing of a trip ticket. This ticket is used during the scheduling process at the present time and is also useful for backup purposes in case of computer breakdown. Large scheduling boards are used in conjunction with the trip tickets to develop the daily schedules of the vehicles.

TRIP SCHEDULING

At some point in time, the scheduler will create and organize vehicle runs either on the computer system or manually using information produced by the computer. The vehicle runs are entered into and stored in the computer and can usually be viewed on the video terminal or printed in the form of driver run sheets. Cancellations will be deleted from the runs and additional requests will be added up until the

established cutoff time. The aggregated runs are called the schedule. The dispatcher will then either distribute the run sheets to the drivers directly or will verbally notify drivers of stops via a radio system.

An obvious consideration in scheduling a trip is to determine which vehicle runs are headed in the direction of the trip request at the time that service is desired. The scheduler attempts to insert the trip at a minimum distance from an existing vehicle within a reasonable time window of the requested time so as to minimize the vehicle's travel time. At the same time, a number of checks must be made to prevent an illegal assignment, such as a dropoff occuring before its pickup or the capacity of the vehicle being exceeded. The scheduler must also ensure that the pickup and dropoff are assigned to the same vehicle and that a wheelchair-bound passenger is assigned a vehicle with a lift. In a computer-aided system, these checks should be done automatically.

Run Registration

With all systems, a vehicle run is defined as a continuous period or piece of work. Each run is identified by a unique run number and has a start time, finish time, driver and vehicle. In computer-aided scheduling systems, runs are first registered giving information on operating times and vehicle type. These runs are then scheduled to the appropriate master and daily schedules and trips are assigned to the runs. With the proposed GIRO/Acces system, if service hours are modified, the system would verify that the changes do not conflict with trips that are already scheduled. In the Ellis/DATS system, a run cannot be shorten if a trip is scheduled outside the shortened run time.

In computer-aided reservation systems, the vehicle runs are established after the daily schedule has been created (although they may not change much from day to day) and each run number is assigned to a trip request manually using either individual trip tickets or sorted lists of trip requests to aid in the process. Start, stop and break times may be prescheduled but are usually recorded during the statistical reconciliation process from the driver run sheets.

Schedule Creation

In special transit service operations, a large portion of trip requests are for regular or subscription service. All regular trips are assigned to a 'master' schedule file and remain relatively permanent for an extended period of time. The advance reservations are stored in a trip reservation file and then merged with a copy of the master schedule for the current day to produce the current trip list for the day. The trip lists are then used by the schedulers to produce the 'current' schedule for the day. Finally, immediate response requests are assigned by the schedulers to existing runs as these requests are received.

GIRO/Acces and Ellis/DATS allow the definition of seven master schedules that describe regular runs and regular subscription trips. These master schedules are used to initialize operating schedules up to seven days in advance for a particular date. Regular trips that have been temporarily cancelled or have expired are not copied into the dated schedule. For special dates and holidays, dated schedules can be built in advance. Comshare/DARTS uses one master schedule which is updated when converted to the current schedule using day of the week codes. With the BC Transit/DART system, the master schedule is essentially the trip scheduling board which holds all the regular subscription trips.

Advance bookings and same day demand-responsive requests are added to the appropriate daily schedule. Requests for regular service are inserted into the appropriate master schedule. Special holding runs are created in the GIRO/Acces system in each schedule in order to store trips waiting to be scheduled; other runs exist for trips that have been cancelled or refused. Special runs can be created for trips to be sent to taxi companies. For these runs, scheduling may or may not be supplied by the special transit operator.

Scheduling Building

The present GIRO/Acces and BC Transit/DART systems print trip tickets which are used by the schedulers in boards to produce schedules manually. The use of trip tickets means that the regular subscription tickets and their position in the boards do not have to change every day. The Comshare/DARTS system prints trip lists sorted by time to assist the scheduler in assigning vehicle runs to the trips. The CSG/ParaTranspo system aids the scheduler by sorting the trips in a daily trip list by time slot, special handling (wheelchair), and city zone. The scheduler can then use this information to assign vehicle runs to each trip and then re-enter the vehicle run numbers into the computer. Each trip request can then be printed on the appropriate driver's run sheet.

The proposed GIRO/Acces system and the existing Ellis/DATS system do not automatically build vehicle runs; they do, however, include a series of aids that facilitate the scheduling process. The trip suggestion algorithms are used to insert a trip into an existing master schedule. They take into account several factors including vehicle capacity, vehicle type, operating hours, as well as vehicle availability and location based on trips already scheduled. These algorithms 'suggest' a list of the most probable vehicles available to meet a particular trip request. Scheduling can be done in two modes: immediately, when the client places his request, or later, when a certain number of reservations have been accepted. Although the trip insertions can be done automatically in the Ellis/DATS system (and is planned to be incorporated in the GIRO/Acces system), this feature is rarely used since the schedulers tend to check the insertions as they are performed.

Travel times used in the suggestion algorithms are calculated using a zone-to-zone time matrix. The time 'windows' of each trip (into which the vehicle run must fit) used by the systems during the suggestion process depend on a series of parameters that may be defined by the operator depending on its policies. These parameters include maximum travel time, wait times and so forth.

It should be noted that specification of time windows by themselves is insufficient criteria for insertion of a trip. The Ellis/DATS system has found that inconsistencies in trip assignments will occur unless vehicle location is also considered. The Ellis/DATS system is also input-output (I/O) bound; that is, an inordinate amount of time is spent reading information from the disk memory storage devices and writing the information back to the disk. The result, due partly to the hardware, is that the terminal response time for insertion of a trip into a schedule is too slow to be very useful when responding to a client on the phone. The developer has estimated that, with a newer computer, the response times would be 10 to 20 times faster.

The proposed GIRO/Acces system has also been designed to permit the use of automatic scheduling algorithms, which could be used to quickly and automatically produce a 'first-cut' schedule. This schedule could then be verified and modified if necessary by the schedulers. Such algorithms have been recently developed by the University of Montreal's Transport-

Exhibit 9: Scheduling In Toronto

ation Research Centre under a grant from Transport Canada, and they could be added to the basic GIRO system. The algorithms use accurate geocoded addresses (for travel time calculations) which are available from Statistics Canada. This combination of automatic 'run-cutting' followed by computer-assisted human examination and manipulation was used in scheduling systems for regular transit services by GIRO.

VEHICLE DISPATCHING

Dispatching can be divided into two major tasks -- relaying information to the drivers and updating the status of vehicles and requests based on information received from the drivers. Informing the drivers when trips have been scheduled for their vehicles can be performed in several ways. Trips normally scheduled by the schedulers are dispatched in the driver run sheets which are given to the drivers at the start of their run. If the sheets cannot be handed to the drivers, the dispatcher may relay the information verbally by radio.

Some operators believe that conditions on the road change too frequently for driver run sheets to be worthwhile. Traffic conditions, doctors running late, passengers with unknown return times -- all contribute to the difficulties of keeping to a fixed schedule by the drivers. In these cases, the operators dispatch the trips in real-time by radio and only use the daily trip lists as a guide.

Other operators rely heavily on driver run sheets and use the radio system only infrequently, and then only for emergencies. The driver run sheets become the basic schedule for the drivers.

Driver Run Sheets

After the scheduling activities, one of the most important tasks of a computer system is to print driver run sheets for each vehicle run. On each sheet is shown the origin and destination of each trip to be carried that day. Special passenger assistance instructions can also be printed, along with passenger identification information. No-shows, cancellations, and extra-ons can be handled by notation on the run sheets. Also, a copy of the run sheets, but possibly in a different format, can be given to the dispatcher to act as a backup source so that current information can be relayed to the drivers by radio. The driver run sheets can also be used to record and monitor vehicle kilometrage, driver pay hours and service hours.

All of the computer systems that are mentioned in this report can produce both run sheets for the drivers and daily trip lists for the dispatchers.

Monitoring Status

Updating the status of vehicles is usually done using a mobile radio system. The drivers will call in every once in a while or the dispatcher will call the drivers. It would be natural to update as a vehicle reaches a pickup point: the dispatcher would then have immediate information with which to update vehicle status.

The information on vehicle status may or may not be recorded into the computer. Toronto plans to have the dispatchers record the status directly into the computer in order to reconcile their statistics and keep a record of actual versus planned operation under the assumption that after-the-fact reconciliation may not be an accurate indicator of the actual operations.

GENERATING REPORTS

During the day, the daily trip records are completed by the drivers by entering the time and odometer readings on their driver run sheets. In the CSG/ParaTranspo system, for example, it is planned that the actual operating information would be entered into the computer against the scheduled trip data. Against each trip, the user would enter the actual pickup and dropoff times, the pickup and dropoff odometer reading and the cash collected or pass number. Also, a no-show or late-show record may be entered.

Reconciliation of Trip Records

The drivers daily trip records, if entered into the computer system, contain the clients' trip requests and the actual trip data which can be used to audit the transaction file and then be processed by the computer to print daily, weekly, and monthly reports. These reports can then be used by management to monitor and evaluate services and to assist in operations planning. In the current Ellis/DATS system, since the actual trip records are not reconciled with the planned schedules, there is no relevant management information available on the actual operations. In the GIRO/Acces and CSG ParaTranspo systems, this function is not fully operational at the present time, although it is being tested. The reconciliation process is important if actual service information is desired.

In the Comshare/DARTS system, a mass update feature is provided to allow a quick change in a particular field to many records at the same time; for example, if a particular vehicle broke down or a social program was cancelled. In the BC Transit/DART system, the reconciliation is used to ensure that the fares collected are accurate, as well as to post the daily statistical information to a transaction file for management information and report generation purposes.

Report Generation

In addition to monitoring current progress, management should be provided summary reports on vehicle productivity and usage as well as data on travel trends in order to plan and evaluate changes in service. Information such as total passengers by type, trip purposes and fares collected, etc., should be provided for evaluating services and making reports to funding sources and interested policy-setters.

Daily and weekly summaries should be capable of being produced from information contained in the driver-revised run sheets. These summaries should include performance measures such as passengers per vehicle hour, capacity used by time of day, trips per day, trips by purpose, difference between actual/scheduled times, vehicle-hours and vehicle-kilometers, trip distance and trip time distribution, user frequency and distribution.

It should also be possible to provide weekly and monthly summaries of cost and revenue information for cost and budget comparisons, and possibly client and service agency billing. The Comshare/DARTS system, for example, provides monthly accounting statistics to aid in invoicing agencies who subsidize certain clients. Other desirable features would include the automatic production of client mailing labels, so that brochures and other target marketing materials could be sent to clients, and the tracking of vehicles by distance, so that specified service intervals could be flagged for vehicle servicing and maintenance. The BC Transit/DART system, for example, can provide a mailing list by location or disability for selective mailing of service information.

The BC Transit/DART system provides information on revenue-hours of service, kilometers travelled, fuel consumption, fares collected and number of passengers carried by individual vehicle and day of service. The planned CSG/ParaTranspo system provides extensive weekly and monthly operational summaries, financial reports and exception reports. The Giro/Acces reporting function is still in the design stage. All the systems produce reports that are customized for a particular operator and are essentially fixed in format -- only the CSG/ParaTranspo system, using the DATATRIEVE query language package, allows the operator to query the data base and produce their own reports. With the Comshare/DARTS system, if the full ZIM development system is obtained, the data base can also be queried and ad hoc reports produced.

5. ELEMENTS

In this chapter, a more detailed review and comparison is provided of the various computer applications in special transit services. In the review that follows, the discussion focuses on the files, records and reports that are used and produced by the system applications. The concepts used are explained below:

File - comparable to a file cabinet holding data pertaining to a particular topic; for example, client file, employee file, vehicle file -- a file contains a group of records. A **master** file rarely has changes made to it and remains stable for lengthy periods. A **working** file contains information which is constantly changing.

Record - a basic component of a file and contains all pertinent information about a particular entity within a file. For example, in the client file, for each client, there will be a record which might contain a client's name, address, phone number, identity number and possibly other information. **Data Element** - is the basic component of a record. Each data element is a single item of information; for example, the client's name.

Report - consists of messages (output) to assist in decision-making. They are produced from information in the files. Most reports take the form of lists and may be as comprehensive as the user specifies, although most systems require special programming to produce custom reports.

The system user manuals were used in the following review. It should be noted that the information is based on what the systems currently do -- and not on what they could potentially do or contain.

FILES

The common and most important files that are used in computer applications for special transit services are the client registration file, trip request or holding file, master and current schedule files, and trip log or transaction file. Other files are more or less utility files that support the features and functions of the major files.

Client File

The client file contains all necessary information on each registered user such as client name, registration number, municipality, zone, birthdate, sex, telephone number, disability code, mobility code, ability to use taxis, escort required, etc. Consequently, this file can become rather large. When registered, each client is automatically assigned a sequential client

DATA ELEMENTS		BC Transit DART	CSG ParaTranspo	GIRO Acces	Comshare DARTS	Ellis DATS	Systemoid TAQM
REGISTRATION	client registration number	●	●	●	●	●	●
	client name	●	●	●	●	●	●
	client address	●	●	●	●	●	●
	client telephone number	●	●	●	●	●	●
	postal code of address	●	●	●	●	●	●
	zone/coordinate of address	●	●	●	●	●	●
	business telephone number	●	●	●	●	●	○
	client date of birth	●	●	●	○	●	●
	client language	○	○	●	○	●	●
	client sex	○	●	●	○	○	○
	client disability code	●	●	●	●	●	●
	special equipment code	○	●	●	●	●	●
	agency billing code	○	○	●	●	●	○
	registration status (perm/temp)	●	●	●	○	●	●
	registration expiry date	○	●	●	○	●	●
	escort or attendant required	●	●	●	●	●	●
	doctors name	●	●	○	●	●	○
	doctors address	●	●	○	●	○	○
	doctors telephone number	●	●	○	●	●	○
	start date of holiday/suspension	○	○	○	○	●	●
	end date of holiday/suspension	○	○	●	○	●	●
	client temporary address	○	●	○	●	○	●
	common pickup address	○	●	○	●	○	●
	frequent destination addresses	○	●	●	●	○	●
	date of last trip request	○	●	●	○	○	○
	number of trips made to date	○	●	●	○	○	●
	number of no shows to date	○	●	●	○	○	●
	number of late shows to date	○	●	●	○	○	○
	number of refusals to date	○	○	●	○	○	○
	number of cancellations to date	○	○	●	○	○	●
	notes and/or comments	●	●	●	○	●	○
	registration/modification date	●	●	●	●	●	○
	operator identification number	○	●	●	○	●	●
RESERVATION	client registration number	●	●	●	●	●	●
	trip identification number	●	●	●	●	●	●
	date that trip was requested	○	●	●	●	○	○
	operator identification number	○	●	●	○	●	●
	type of trip (subscr/reservation)	●	●	●	●	●	●
	number of passengers by type	●	●	●	○	●	●
	fare for the trip	●	○	●	○	○	○
	ticket or agency to be billed	○	○	●	●	○	○
	date (days of week) of trips	●	●	●	●	●	●
	start date of regular trips	●	●	●	○	●	●
	end date of regular trips	●	●	●	○	●	●

Exhibit 10: Comparison of Data Elements

number. These files are normally ordered by registration number with a subfile cross-referencing a person's last name to the registration number. The information contained in this file is used to automatically assign correct address information during the trip reservation process, to maintain an up-to-date list of eligible clients and to provide information for the drivers who are to service the client.

In addition to entered data, the CSG/ParaTranspo and GIRO/Acces systems are planned to accumulate data on each client. This data will include number of trips made, number of no shows, and number of late shows. The GIRO/Acces system will also accumulate number of refusals and number of cancellations. This information may be used to make decisions on client deregistration, investigate complaints and to provide general statistics on ridership. The Comshare/DARTS system also accumulates this information but in a separate client statistics file.

DATA ELEMENTS (cont'd)		BC Transit DART	CSG ParaTranspo	GIRO Acces	Comshare DARTS	Ellis DATS	Systemoid TAQM
RESERVATION (cont'd)	pickup address	●	◒	●	●	●	●
	time	●	◒	●	●	●	●
	zone/coordinate	○	◒	●	○	●	○
	notes or comments	○	○	●	●	●	○
	telephone number	○	○	●	●	●	●
	dropoff address	●	◒	●	●	●	●
	time	●	◒	○	●	○	●
	zone/coordinates	○	◒	●	○	●	○
	notes or comments	○	○	●	●	○	○
	telephone number	○	○	●	○	○	●
	pickup time for return trip	○	◒	●	●	●	●
	trip purpose code	●	◒	○	○	●	●
	client disability code	○	◒	◒	●	●	●
	special equipment code	○	◒	●	●	●	○
	status of the trip (scheduled, etc.)	○	◒	●	●	○	○
	degree of flexibility in trip time	○	○	●	○	○	○
	beginning holiday/cancellation date	●	◒	○	●	●	●
	ending holiday/cancellation date	●	◒	○	●	●	●
	comments for driver	●	○	●	●	●	○
SCHEDULING DISPATCHING	same as reservation data elements but ordered by day and vehicle run						
MONITORING	vehicle number	●	◒	●	●	●	●
	vehicle type/description	●	◒	◒	○	●	○
	vehicle division/company	○	○	◒	○	○	○
	start time	●	◒	◒	●	●	○
	end time	●	◒	◒	●	●	○
	odometer reading start	●	◒	○	●	●	○
	odometer reading end	●	◒	○	●	●	○
	arrival time at a stop	○	◒	○	○	●	○
	departure time at a stop	○	○	○	○	●	○
	odometer reading at a stop	○	○	○	○	○	○
	fare collected from passenger	●	◒	○	●	○	○
	total hours of operation	●	◒	○	●	○	○
	total kilometers travelled	●	◒	○	●	○	○
	total passengers carried	●	◒	○	●	○	○
	total fares collected	●	◒	○	●	○	○
	productivity of service (psgrs/hr)	○	◒	○	◒	○	○
	utilization of service (load/capacity)	○	◒	○	○	○	○
	average vehicle speed	○	○	○	○	○	○
	average deadhead time	○	○	○	○	○	○
	average passenger wait time	○	◒	○	○	○	○
	average passenger ride time	○	◒	○	○	○	○
	average cost per trip	○	◒	○	○	○	○

● - operational ◒ - being tested

Exhibit 10: Comparison of Data Elements (cont'd)

Master Schedule File

The second file of interest to the special transit service operator is the master schedule file. Regularly-scheduled subscription trips are usually the basis for the service patterns accommodated by the special transit service. Consequently, subscription trips tend to drive the entire system. Daily trips are scheduled around the service created to serve the subscription trips.

The master schedule can, of course, be changed, but it is designed to assist the operator in formulating actual daily or current schedules. The master schedule contains all the regular or recurring trip bookings for those passengers who go to the same destination the same day each week.

There is usually a master schedule for each day of the week (Monday through Sunday) for each vehicle normally in operation on that day of the week. Comshare/DARTS uses one master schedule file with day codes. It also has a 'holiday' file to ensure that the master schedule is not used on these days. These schedules should be easily accessed and changed at the operator's discretion.

To initialize a current schedule for the current day, both the Ellis/DATS and the CSG/ParaTranspo systems copy the master schedule for that day of the week with the vehicle assignments on them from the previous week's schedule. Regular trips that have been cancelled are excluded.

Trip Request File

The trip request file contains all the advance reservation and demand-responsive trips that clients have requested but have not yet been scheduled. The GIRO/Acces system creates special holding runs in each schedule to store trips waiting to be scheduled. The trip request file would contain all the necessary information on each trip request, such as name, address, destination, time of day and day of week.

The Comshare/DARTS and CSG/ParaTranspo systems sort, display and print the trip request file so that driver run assignments can be attached to each trip. The BC Transit/DART and GIRO/Acces systems print out individual trip tickets showing the information contained in each record of the trip request file.

Current Schedule File

In establishing the current schedule for a particular day, an operator would normally call up the master schedule for that day and use it as the basis for defining a new schedule that might also contain all the advance reservation trips for the current day. The operator should be able to add trips to this starting schedule, delete trips from it, or move trips around.

Therefore, this is a working file. No changes should be made to the master schedule at this point unless the master schedule is specifically modified.

All the systems use this basic procedure for developing the vehicle schedules for a particular day of the week.

Trip Log File

The fourth major file of computer systems for special transit services is the trip log or transaction file. Simply stated, this is a log of all trips made by the clients. This is usually designed to be a monthly log, however, the reporting or summary of trips can usually be made at any time.

Usually, the drivers would return with their trip sheets at the end of each day with indications as to no-shows, any changes in schedule which occurred during the day, and odometer readings. These changes and odometer readings would then be entered into the schedules by the user so that the daily schedules for that day reflect what actually happened. Once these entries are made, the day's activities are logged to the trip log file. In the BC Transit/DART and Comshare/DARTS systems, once the trips are posted to the month-to-date statistics file, the individual trip information cannot be accessed, only the cumulative totals are retained.

Vehicle File

The vehicle file contains a list of vehicles assigned to the custom transit service with their type and capacity. This is important for the scheduling process when the capacity of each vehicle can be checked against bookings to make sure seats are available. Depending on the requirements of each transit operator, other information is stored in the vehicle file (hours of operation, kilometers, etc.). The BC Transit/DART system keeps all of its information by vehicle number, rather than by client. The GIRO/Acces system is designed so that the contents of this file may vary from one operator to another, in order not to duplicate information collected by other systems (a fleet maintenance system, for example).

Driver File

The driver file, as proposed by GIRO/Acces, contains a list of the identification numbers of the drivers working for the operator along with their name and any special classification. The CSG/ParaTranspo system is similar. Other information can be stored in this file (hours worked, accidents, etc.) if required. The contents of this file may vary from one operator to another in order not to duplicate information collected by other systems (a payroll and accounting system, for example).

ELEMENTS

Common Address File

The clients of special transit services frequently have common destinations: hospitals, shopping centres, medical clinics, etc. Many live in specialized institutions. The use of a common address file allows an automatic determination of commonly-used addresses and locations.

The GIRO/Acces, Ellis/DATS and CSG/ParaTranspo systems allow the definition of a series of abbreviations of common addresses. For example, TGH could be the code used for Toronto General Hospital; when entered, the system would automatically complete the street address. This feature helps speed up data entry and has the added advantage of standardizing address formats.

Transaction File

The GIRO/Acces, Ellis/DATS and CSG/ParaTranspo transaction file has a log of all important system user actions. Each time a client record is modified, a trip is scheduled, or a trip is cancelled, an entry is added to this file. File contents are accessible either by client number and date or by operator identification number and date. This log file is very useful when tracking down errors and/or investigating complaints or queries.

REPORTS

The main reports that are produced by the various computer systems include driver run sheets, operating summaries and financial statements. Other potential reports would include: mailing labels, client and agency invoices, and trip tickets. Various lists can also be provided with some systems, such as a list of active clients (clients who have used the system in the last period), lists of clients with expired eligibility, disability codes listing, agency listings, common address listings, etc.

With most systems that were reviewed, the reporting function is the last function to be computerized and the system developers indicate that, since every transit property seems to desire a unique format for their reports, the reporting function has to be more or less customized for each installation. Only the CSG/ParaTranspo system offers a means of producing 'ad hoc' reports fairly easily.

Driver Run Sheets

Driver run sheets would list the trips to be serviced during the day for each vehicle run. The information contained would include client name, address and time of pickup or dropoff with room for the driver to fill in actual times of pickups, as well as odometer readings and fares collected.

REPORTS		BC Transit DART	CSG ParaTranspo	GIRO Acces	Comshare DARTS	Ellis DATS	Systemoid TAQM
REGISTRATION	client registration list	○	●	●	●	●	●
	client file maintenance list	●	○	○	●	○	○
	client registation forms	○	○	○	●	○	○
	client identification cards	○	○	◒	○	○	○
	client distribution by variables	○	○	●	○	○	●
	client's travel history	○	○	○	○	○	○
	client's no show, late show rate	○	○	○	○	○	○
	expired registrant's report	○	●	●	○	●	○
	inactive registrant's report	○	●	●	○	●	○
	selective mailing labels	●	○	○	●	●	○
RESERVATION	advance reservation report	○	○	○	●	●	○
	immediate reservation report	○	○	○	●	○	○
	subscription reservation report	○	○	○	●	●	○
	subscribers trip deletion report	●	○	○	○	○	○
	current trip list by client	○	○	○	●	○	○
SCHEDULING	trip request list by time	○	◒	○	●	●	●
	trip request list by disability	○	◒	○	○	○	○
	trip request list by location	○	◒	○	○	○	●
	individual trip tickets	●	○	●	○	○	●
	master schedule list	○	○	◒	●	●	○
	current schedule list	○	○	○	●	●	○
DISPATCHING	driver run sheets	●	◒	◒	●	●	○
	daily trip list for dispatcher	○	◒	◒	●	●	●
	daily transaction activity	○	○	○	○	●	○
	call-back confirmation list	○	○	◒	●	○	○
MONITORING	daily operational summary	●	◒	◒	●	○	●
	weekly operational summary	○	◒	◒	○	○	●
	monthly operational summary	●	◒	◒	●	○	●
	number of trips by time	○	◒	○	○	○	○
	performance by time	○	◒	○	○	○	○
	statistics by vehicle run	●	◒	○	○	○	○
	trip and cancellation summary	○	◒	○	●	○	○
	service levels and performance	○	◒	○	○	○	○
	origin-destination trip frequency	○	○	○	○	○	○
	daily financial summary	○	○	○	○	○	○
	weekly financial summary	○	◒	○	○	○	○
	monthly financial summary	○	◒	○	●	○	○
	customer billing reports	○	○	○	●	○	○
	agency billing reports	○	○	○	●	○	○
	contractor monitoring reports	○	◒	○	○	○	○
	summary financial information	○	◒	○	○	○	○
	operation exception reports	○	○	○	○	○	○
	driver statistics reports	○	○	○	○	○	○
	office transaction activity	○	○	○	○	○	○

● - operational ◒ - being tested

Exhibit 11: Comparison of Reports

Daily Trip Lists

Daily trip lists would contain the same information as the driver run sheets but would be ordered by time, rather than vehicle run and time, for use by the scheduler in assigning vehicle runs to the trips and by the dispatcher in monitoring the daily service. In addition to sorting the trips by time, the CSG/ParaTranspo system sorts the trips by handling requirements (wheelchair, etc.) and by city zone.

Included in this category of reports, would be the trip tickets produced by the GIRO/Acces and the BC Transit/DART systems.

Operating Summaries

Operating summaries would list summary totals of information contained in the driver run sheets and should probably be reconciled with the revised driver run sheets containing actual information. The difference between the actuals and the planned (for example, difference between scheduled pickup time and actual pickup time) could then be used to monitor the performance of the system.

The proposed weekly CSG/ParaTranspo operating summary, for example, would indicate the hours of service, vehicle kilometres, number of passengers, number of no shows and number of trips by type. The Comshare/DARTS system provides a monthly summary showing similar information.

Financial Reports

Financial reports, as with the CSG/ParaTranspo system, are an accumulation of financial data based on the weekly operating statistics and are the basis for determining the contract payments. A financial summary, containing selected data from the financial report, is also available.

Financial summaries generally require input of the financial data on behalf of the operator. Such information as cost of service, vehicle lease payments and operating costs are usually calculated separately. This information could, however, be incorporated into the budgeting information to produce the comprehensive operating and financial statements.

6. FEATURES

The purpose of this chapter is to provide a review of some of the ancillary features of the various computer applications, as well as their capabilities (response times) in performing some rather simple functions.

Aside from the scheduling function, all of the computer applications appear to have similar broad capabilities in the areas of client registration, trip reservation and report generation. The differences tend to appear when considering specifics, such as the manner in which the system handles no shows or the manner in which the information is reported at the end of the month. These are items that each individual operator has to prioritize in order to properly evaluate and select the desired functionality.

An emphasis was placed in this report on the functionality of the systems, but a major difference between the systems is found in their configurations. The CSG/ParaTranspo and Systemoid/TAQM systems, for example, operate on DEC VAX minicomputers while the BC Transit/DART and Comshare/DARTS systems operate on IBM Personal Computers, the Comshare system being a multi-user system and the BC Transit system being developed for both a multi-user and single-user environment. The GIRO/Acces system operates on both a PRIME 550 minicomputer and an IBM Personal Computer. The Ellis/DATS system is currently operating on a Hewlett-Packard 3000 Series III minicomputer.

Some of the ancillary and utility features of the various systems, such as access security, documentation, degree of integration, and ease of operation are discussed on the following pages.

FEATURES

Operational Efficiency

The computer application should run smoothly and efficiently. If an application has been well thought out, it will provide a number of features to reduce the tedious workload associated with the data-entry process, while protecting the operator from entering erroneous information. Data should be checked upon input and rejected if found to be invalid -- for example, a client registration number not previously set up in the system. Menu selections should follow a logical sequence and should lead the user into the desired data-entry screens. They should be easily traversed and self-explanatory. Above all, the program should be reliable enough so that it does not crash and leave the operator high and dry when it encounters invalid input.

Computer systems should be logical, simple to use, easy to learn and designed to provide a 'user-friendly' environment. They should assist the operator with prompts and guides, adequately spelling out the possible choices to the user. Usually, this means that the system would be menu-driven but the use of function keys is also quite popular.

There appears to be a certain amount of controversy in the literature concerning the use of menus versus function keys. Dedicated function

FEATURES		BC Transit DART	CSG ParaTranspo	GIRO Acces	Comshare DARTS	Ellis DATS	Systemoid TAQM
OPERATION	menu driven/built-in commands	●	○	●	●	●	●
	dedicated function-key driven	○	●	○	●	○	○
	forms-oriented data entry	●	●	●	●	●	●
	data entry validation/look-up tables	●	●	●	○	●	●
	valid options always displayed	○	○	●	○	○	●
	extensive use of codes and defaults	○	●	●	●	○	●
	understandable error messages	○	●	●	●	●	●
LEARNING	user manual and documentation	●	●	●	●	●	●
	on-line or disk tutorial	●	○	○	○	○	○
	function key overlay guide	○	●	○	○	○	○
	on-line help messages	○	●	●	○	○	●
INTEGRATION	integrated file structure	○	●	●	●	●	●
	consistent command structure	○	●	●	●	●	●
	consistent format structure	●	●	●	●	●	●
	automatic update of screen data	●	●	●	●	●	●
DATA MGMT	field-indexed data base design	●	●	●	○	●	○
	entity-relationship data base	○	○	○	●	○	●
	file sharing capabilities	○	●	●	●	●	●
	record sharing capabilities	○	○	○	○	○	○
SECURITY	multiple access levels	○	●	●	●	●	○
	password protection	○	●	●	●	●	●
	operator ID number recorded	○	●	●	●	●	●
AUDITING	provides transaction record	○	●	●	●	●	●
	operator ID and date noted	○	●	●	○	●	●
	balancing of daily transactions	●	○	○	○	○	○
	archiving and retrieval	○	○	○	○	○	○
REPORTING	menu driven with fixed list	●	●	●	●	●	●
	allows wild-card parameters	○	○	○	○	○	●
	has compound search criteria	○	○	○	○	○	○
	query selection capabilities	○	●	○	○	○	●

Exhibit 12: Comparison of Features

keys perform unique functions on the keyboard. Cursor control is perhaps the most familiar of the dedicated functions. A menu is a list displayed on the screen of various functions that the user can perform. Menus reduce operator training since they are simpler to remember and use, but they also tend to slow down transactions for individuals who are using a single part of the system quite regularly.

In the GIRO/Acces system, most actions taken by the user are menu driven. This means that at each step, a list of possible actions is displayed on the screen. The user can then hit the number or letter corresponding to the action chosen and request the computer to perform the action. Both the Comshare/DARTS and CSG/ParaTranspo systems make extensive use of function keys to assist the operator. The BC Transit/DART system makes use of single-character English commands and the Ellis/DATS system uses two-character commands.

All entered data should be automatically validated for inconsistencies or errors. Meaningful error mesages should be displayed and provision made for a smooth and efficient means of recovering from and correcting errors. Error detection and handling vary considerably. The Comshare/DARTS system has extensive error detection, display and handling features since it was developed from a successful commercial database management system. The GIRO/Access system displays the number of 'serious' and 'other' errors and each screen before the information is transmitted into the proper file. The BC Transit/DART system will not allow transmission of inaccurate data into a file, but does not display the reason for the errors. If information in a field is incorrect, it is sometimes difficult to understand why.

The number of keystrokes required to implement each operation should be minimized, for example, by providing for the entry of a simplified code or abbrevation in place of a full description. But it should be easy to access the codes during the data entry process. The GIRO/Acces and CSG/ParaTranspo systems make extensive use of common address and common destination codes. All systems have codes to describe disabilities and special requirements of their passengers.

User Documentation

Quality system documentation is important for any software product. The material should be clear, logical in sequence and concise. Explanations should be provided for such things as copying the operating system to the program diskettes or for downloading the programs to a hard disk. The manuals should contain an index, a glossary of both computer and accounting terms, and a table of contents. Sectional tabbing significantly reduces referencing time. Manuals providing examples by illustration are particularly effective in decreasing the learning time. Well-conceived tutorials are almost essential when adapting to programs of this nature.

An on-line help command in the GIRO/Acces system provides information on system use, with references to appropriate sections of the user manual indicated. A similar on-line help command is available with the CSG/ ParaTranspo system.

Functional Integration

By definition, integration means 'united'. Simply put, an integrated system unites its various components under a single architecture through which they share common commands, file structures, special-function keys, and data. The system may appear to the user to be one program with many functions, or a number of programs accessed from a common menu.

The advantages of an integrated system are increased operator productivity and reduced operator training time. Additionally, a significant decrease in input error should be realized by the elimination of redundant data input.

Generally speaking, an integrated system permits user access to all the system functions through a single menu, using one standard set of procedures. Above all, data entered into any of the system's modules need only be input once. The dissemination of data to all affected modules requires little or no user interaction. Most of the systems appear to be functionally integrated, except for the BC Transit system which is essentially two differenct systems accessed from different menus -- a client registration and reservation system and a separate trip statistics system.

Data Management

Computer applications for special transit services are built around database managers as a way of storing the vast amounts of data required and of increasing end-user productivity. Generally speaking, a program based upon or built around a database management system affords the user more flexibility in the manipulation of data. For example, the program permits customization of standard reports.

The use of a database manager allows the user to pull specific information from anywhere in the system and report on it in any format he specifies. This enables the user to focus on a particular problem area. Reporting flexibility is one of the benefits of the database design. Others include the ability to design and print mailing labels.

The database structure of the CSG/ParaTranspo system allows for the use of a software package to produce ad hoc reports. The database structure used in the Ellis/DATS client file is highly structured and inflexible and certain data fields (such as no-shows) have to be entered by line number. The extraction of statistical information on clients, which should be a

simple exercise, can be quite problematic, requiring special program development. In the Comshare/DARTS system, the full ZIM database development system, rather than just the runtime system, would have to be obtained and learned in order to develop special ad hoc reports.

Access Security

To minimize the risk of unauthorized access to confidential information, the program should provide some sort of password protection. Security of access and file protection restricts system entry, modification and deletion of information to those individuals whose responsibility it is to maintain the designated files. For example, the scheduling functions could be restricted to the scheduler or dispatcher, modification of vehicle runs could be restricted to the supervisor, and modifying a registration record could be restricted to a registration officer. This feature reduces the likelihood of certain information being changed by unskilled or unauthorized users. The level of security currently available ranges from none at all in the BC Transit/DART system to the ability to limit access to individual system functions by the CSG/ParaTranspo system.

With the GIRO/Acces system, up to seven levels of access security can be defined. Depending on the user's code, he or she may be limited to certain system functions. For example, some users may not be allowed to modify the client's file although they may consult the file. The Comshare/DARTS and CSG/ParaTranspo systems also have various levels of access security.

Auditing Capabilities

Any records no longer required, which are deleted from the system, should be archived on tape or disk and restoration of the information should be readily available.

Archiving, purging and file reorganization are accomplished by a series of utility programs provided with GIRO/Acces. Historical schedules and clients whose registration has expired are archived on disk at regular intervals (weekly or every two weeks). In both the BC Transit/DART and Comshare/DARTS systems, once the trip data is posted to the statistics files the individual trip records are no longer accessible.

Both the GIRO/Acces and CSG/ParaTranspo systems keep track of changes to records by noting the operator identification number and date on each record that is modified.

In the BC Transit/DART system, transactions will not be posted to the statistics file unless the batch process is in balance.

FEATURES

Reporting Capabilities

The ability to generate management information reports is really what distinguishes a management information system from an information processing system. Reports should be as flexible as possible in design and layout so that they can meet the present and future reporting needs of the operator. The significance of good reports cannot be overstated, as they provide critical management-decision information with respect to such things as budget requirements or the tightening of service provision.

Of the various computer applications, report formatting ranged from nonexistent to only partially user-definable. Generally, the systems come with a specific reporting format that can only be adjusted by the system supplier, while the Comshare/DARTS and CSG/ParaTranspo systems are based on a database design and report generator permitting the user to tailor reports to their own specifications to a certain extent. While total customization is certainly the most desirable, it should also be easy to accomplish.

PERFORMANCE

The observed performance of each of the computer systems is shown in the Exhibit 13. It should be noted that some of the performance figures were based on observance of test systems and not fully configured and operational systems. In several cases (Ellis/DATS and Comshare/DARTS), the developers felt that the response times would decrease considerably if the software was installed on an IBM PC/AT.

Registration

The most time-consuming part of the client registration function is entering the required data in the form on the screen. Since this function is usually performed off-line with the client's application form being used to provide the information, the time constraints are not critical to the successful operation of the system.

Reservation

The most time-consuming part of the trip reservation task is talking with the client on the phone. This time varies considerably, depending on how fast the client and the reservationist can communicate and how much information needs to be collected. The computer contributes significantly in reducing the total task time. If the caller's registration number (or name) is known, substantial time can be saved because the reservationist need not type in the pickup and delivery addresses.

PERFORMANCE		BC Transit DART	CSG ParaTranspo	GIRO Acces	Comshare DARTS	Ellis DATS	Systemoid TAQM
REGISTRATION	accessing the client file	8 sec	5 sec	2 sec	8 sec	8 sec	n/a
	entering the information	2 min	2 min	2 min	2 min	2 min	n/a
	finding a particular client						
	registration number known	15 sec	2 sec	2 sec	12 sec	8 sec	n/a
	registration number not known	15 sec	3 sec	3 sec	15 sec	10 sec	n/a
	with a common name	20 sec	n/a	5 sec	20 sec	n/a	n/a
	modifying client information	1 min	1 min	1 min	1 min	1 min	n/a
	deleting an inactive client	10 sec	30 sec	30 sec	n/a	n/a	n/a
RESERVATION	accessing client's trip file	15 sec	5 sec	3 sec	10 sec	10 sec	n/a
	entering in the information	90 sec	60 sec	45 sec	60 sec	90 sec	n/a
	using default or coded values	80 sec	50 sec	30 sec	50 sec	80 sec	n/a
	booking the return trip	10 sec	10 sec	10 sec	10 sec	10 sec	n/a
	cancel/query a request	20 sec	10 sec	8 sec	15 sec	15 sec	n/a
	computer processing time	5 sec	1 sec	1 sec	4 sec	8 sec	n/a
SCHEDULING (for 200 trips)	sort and display/print trips	15 min	5 min	10 min	5 min	n/a	n/a
	assign vehicle run numbers	3 hrs	2 hrs	3 hrs	2 hrs	n/a	n/a
	merge into daily schedule	5 min	2 min	1 min	20 min	n/a	n/a
	display vehicle run on screen	n/a	n/a	3 sec	n/a	yes	n/a
	insert trip request into run	n/a	n/a	n/a	n/a	8 hrs	n/a
DISPATCHING	print driver daily run sheets	15 min	5 min	5 min	10 min	5 min	n/a
	update current daily schedule	n/a	10 sec	n/a	n/a	n/a	n/a
MONITORING (for 200 trips)	reconcile driver trip logs	2 hrs	1 hr	n/a	1½ hrs	n/a	n/a
	print daily operating summary	5 min	5 min	n/a	5 min	n/a	n/a

Note: times are rough estimates based on general observance of the systems

Exhibit 13: Comparison of Performance

Scheduling

With most computer-aided systems, the actual user time is the time that it takes the scheduler to make his or her decision known to the computer -- and this time can very considerably depending on the skill of the scheduler. The computer processing time will then vary depending mainly on the number of trips being processed at a time.

With the computerized systems, offering trip insertion algorithms, the computer processing time appears to vary widely. The Ellis/DATS system takes between two and seven minutes to insert a trip depending upon the number of users on the system, while the GIRO/Acces system appears to be almost instantaneous (albeit in a test mode only).

Monitoring

The performance of the systems in the monitoring function is where the most benefits over manual systems are visualized. However, it is the function that is the most difficult to provide meaningful performance measurements since the time depends so much on the speed of the printer being used to produce the reports and the number of items being reported.

7. CONCLUSIONS

TRENDS

Although it is not clear that computerized scheduling by itself will improve productivity, it is clear that the use of computers in special transit services can help eliminate the extensive amount of paperwork now undertaken as well as provide management with immediate and usable information. Some of the other advantages include: better customer response, better quality service, immediate and better records and summaries of individual driver activity, and a means of monitoring relative wear and need for vehicle maintenance.

Given the present state-of-the-art, special transit services can best be coordinated at the present time by a computer-aided system. Systems that organize the trip scheduling information for the scheduler -- but do not make any decisions on trip assignments -- are further developed than existing and proposed automatic scheduling systems.

The emphasis in developing automated scheduling systems is on the development of trip insertion algorithms for inserting trips into an existing master schedule. This approach bypasses the question of whether or not computerization of the scheduling task will result in increased productivites and more trips being satisfied. The proposed GIRO/Access automatic scheduling algorithm has only been tested and no operators have established a date for implementation. The Ellis/DATS automatic scheduling system has been hampered by poor system architecture, data base design and obsolete equipment surrounding a fairly successful trip insertion algorithm.

CONCLUSIONS

For the computer-aided system design approach, some questions such as the relative efficiency of 'deferred' versus 'immediate' scheduling are still unresolved. Deferred scheduling in which the scheduling process is performed after all the requests are known is preferred by Toronto but results in an expensive call-back process to confirm trips. Most other operators prefer to provide immediate scheduling answers to clients when the client phones to request the trip -- even if this means that trips that can't be scheduled have to be placed on a supplementary taxi service.

Although immediate scheduling of trips meets the needs of many operators in providing a responsive and personal service, there are still unresolved questions related to the establishment of 'optimal' or efficient master schedules. Thus, risks associated with conflicts between demand levels and fleets sizes, or the relative efficiency of different modes of operation arise. There is a need, therefore, for the planning capabilities inherent in automatic scheduling systems, if only to initialize the master schedules for later trip insertions by computer-aided methods.

Transport Canada has recognized these concerns and has funded two separate projects (in addition, to the funding of the development of the automatic scheduling algorithms at the University of Montreal). One project, jointly funded by BC Transit, as previously mentioned, is oriented towards the development and demonstration of a decentralized dispatch and brokerage computer system for small special transit operators. The other project, jointly funded by the City of Edmonton, is oriented towards the development and demonstration of computer systems for a centralized transportation brokerage operation. Both projects began in the summer of 1985 and are anticipated to take about two years.

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